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Incorporating
Aeronautical Engineering
Edited by - - THURSTAN JAMES

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STILL WAITING TO GO

FIVE WEEKS have passed since we wrote on this page that it was no secret that B.E.A. had decided that the order for its new short-range jet aircraft should be placed with the de Havilland Company at Hatfield. We also reported that the Ministry of Supply was not satisfied that the de Havilland plan for sharing out the work on a co-operative basis met the Government's requirements; we said that what the Government wanted was a merger. Exactly what is wanted by the Government has yet to be defined. Speaking at the B.I.A.T.A. dinner last December, Mr. Watkinson said that the new airliner for B.E.A. would have to be a private venture. The Minister of Supply said in the House: "Lastly, it is desirable that the Industry should reshape itself into stronger units. I have accordingly intimated to the industry that in placing orders for further requirements the Government will be influenced not only by the quality of design, but also by the resources, technical and financial, available to complete the project quickly and successfully; and that in so far as these criteria are not met in isolation, the Government will require the chosen contractor to work in association with one or more other contractors."

Lord Mancroft, in the House of Lords on December 20, said: "So far as development, as distinct from research, is concerned, we hope that the reorganization and strengthening of the Industry will result in manufacturers being themselves in a position to finance both the development and the production of fresh aircraft projects. This, of course, does not exclude the possibility that certain major projects which it may be decided to launch will continue, by reason of their size, to require some measure of Government investment."

As the negotiations progressed it became clear that the Government, working through the Treasury's power of veto over B.E.A., were aiming to achieve a merger of units in the Aircraft Industry to form bigger groups not only with more production capability, of which there is at this time a surplus, but of enhanced engineering and financial resources. It is interesting to see how far a Conservative Government has been prepared to go in reorganizing private enterprise; it will be even more instructive to see how far they go before the matter is finished.

When the accounts of the national Airline Corporations were debated in the House on January 27, Mr. Watkinson, in speaking about the negotiations over the production of a new aircraft to meet B.E.A.'s requirements, said that if there had been some delay, and he did not accept that, six months was no long time in a matter of this complexity, it had been profitably spent because it had ensured that the aircraft offered to B.E.A. were on a private-venture basis. The firms took the risk and would be all the more keen to succeed.

Of the two aircraft manufacturing groups competing for the B.E.A. order, Mr. Watkinson said the Bristol and Hawker Siddeley group, which was offering a medium jet to the general design specification set out by B.E.A., were exploring the market in America. De Havilland's had also set up a group of associated companies and had indicated that they would endeavour to pass on to Saunders-Roe any contract work which the group itself could not undertake. He hoped that within the next few days it would be known how the Bristol-Hawker Siddeley group was getting on in America—he understood they had already had one inquiry—and clearer information would be available about the exact basis on which the de Havilland offer was made.

The partners in the new company are to be de Havillands, Huntings and Faireys. Rolls-Royce has undertaken to provide the powerplant and installation as a private venture. Lord Balniel disclosed that the holdings in the new company would be: de Havillands 67½%, Huntings 22½% and Faireys 10%. Although Handley Page, Ltd., was originally mentioned as being of the Group, it is to be noted that no further information has been forthcoming about the part this company is to play. There are many who believe that the Dart-engined Herald could win a large share of the DC-3 replacement business.

It will now be fascinating to see what solution will be propounded should, as we must all hope, the Hawker-Siddeley-Bristol team return with orders from the United States. How to avoid the resultant duplication of effort will indeed tax the wisdom of a Solomon.

Having made it so clear that the country needs a less-extensive Aircraft Industry, that is so far as Government support is concerned, our legislators have no doubt been giving thought to the question of the numerous administrative staffs concerned with aeronautical affairs in the Air Ministry, the Ministry of Defence, the Ministry of Supply, the Admiralty, the War Office and the Ministry of Transport and Civil Aviation. It is only logical that some form of amalgamation, grouping, pooling or what-have-you should be evolved to reduce these staffs. As for the talented and devoted workers in Government laboratories and research establishments engaged on aeronautical work, their contribution forms a vital part of the export effort and ways must be found to keep them going.

MATTERS OF MOMENT

Bristol Engines in America

THE ORPHEUS turbojet produced by Bristol Aero-Engines, Ltd., is playing an increasingly important part in international aviation and should prove an important item in this country's exports. The latest order for this engine comes from the Lockheed Aircraft Corporation, which has decided to power its second prototype Jetstar utility transport aircraft with two Orpheus. The first Jetstar, which flew last September, was powered by the Orpheus—in fact the immediate availability of this engine helped to bring forward the date of the first flight—but it had been expected that the second aircraft would be American-powered.

The first aircraft has flown successfully on one engine at 20,000 ft., and has made a standing-start take-off on one engine from an aerodrome altitude of 2,200 ft. After 116 hr. of use the Orpheus was in so good a condition that "you could hardly tell it had been run." Ranges of 1,725 miles have been attained, with ample fuel reserves. Speeds of more than 600 m.p.h. have been reached, and the aircraft has climbed to its cruising height of 45,000 ft. within 30 min. of a full-load take-off.

Missile Technology and Security

AN auspicious opening paper, Guidance and Control, was given to the new Guided Flight Section of the Royal Aeronautical Society by Mr. L. H. Bedford, C.B.E., M.A., B.Sc., on January 23. Mr. G. W. H. Gardner, C.B., C.B.E., B.Sc., F.R.Ae.S., the Director of the Royal Aeronautical Establishment, introduced Mr. Bedford, who is now the chief engineer of the Guided Weapons Division of the English Electric Company, having previously worked with the Cossor and the Marconi companies. The paper, he explained, dealt with the guidance and control of guided missiles, the part that is often called the brains of the missile. He said that the lecture which Mr. Bedford had prepared had been heavily censored by the security authorities and that the paper which was to be given was partly a substitute. (A summary of it appears on page 133.)

Mr. Bedford began by apologizing for the general nature of the paper that he had to give. He said that he regretted the cuts which had been made by the security authorities, for he considered that a paper should give practical design calculations, but that these had been cut out by the security authorities.

At this point it is interesting to consider whether the restrictions imposed are wise and balanced. The decision on the degree of secrecy is in the hands of the military security authorities. They see the military need for widespread concealment but they have no responsibility for design development.

At this meeting, some of the meat of the paper, the practical design calculations, was censored and all the men present, many of whom were concerned with guided-weapon development, lost this information. How much damage was done to the future development of our weapons?

Perhaps the need to strengthen our design effort by more published information should be voiced to the security censorship. In an ideal system, these two conflicting requirements could be resolved by an independent authority to whom the opposing views would be put.

Exports Highest Yet

ACCORDING to the S.B.A.C., the British aircraft industry's export total in December—£17,516,043—was the biggest ever recorded in a single month, and brought the year's total to £116,471,110. This total is an increase of 11.5% over the previous record annual figure of £104½ million in 1956, which was itself a 58% increase over 1955.

This means that for the third year in succession the industry has sold more of its products abroad than ever before; since 1954, when exports amounted to £56 million, the total has been more than doubled. Since the end of the War exports have amounted to more than £650 million, of which no less than some £167 million has been through the sale of aero-engines.

The annual figure was made up of £69,767,417 for aircraft and parts; £40,642,162 for engines; £814,340 for tyres; £3,267,975 for electrical appliances, and £1,979,216 for instruments. India was again the best customer, buying almost £11 million worth of aircraft and parts.

DE HAVILLAND CAPABILITY.—Comet production is in being at Hatfield and in the vast 1,000,000-sq. ft. factory at Chester. Below, five Comet fuselages can be seen on their tracks in the fuselage assembly shop at Hatfield. Two more are in the equipment bay. Sections of the Comet hull are in the left foreground. To the right is a pressure dome. Above right, production of the Comet 4 for B.O.A.C. is getting into its stride at Chester.

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Inspection of Wooden Aircraft

TRIGGERED-OFF by the disclosure, during recent examinations, of deterioration in the condition of timber and glued joints in a number of wooden aircraft, particularly those constructed before 1947, the Air Registration Board has introduced new requirements for the renewing of Certificates of Airworthiness. These apply to all wooden aircraft over 10 years of age and to later aircraft if the Board's surveyors consider that their general condition warrants further inspection.

Much, but not all, of the deterioration has been caused by water soakage, and the A.R.B.'s notice to licensed engineers and owners of civil aircraft states that in most cases it has occurred in places where normal inspection is impossible and has not come to light until adjacent structure has been disturbed during modifications or extensive overhauls. The closer examination has revealed failure of glued joints in the primary structure and patches of timber in an advanced stage of decay.

Because the external appearance gives little or no indication of the condition of the timber and glued joints beneath the surfaces, the Board's surveyors will, before renewing Certificates of Airworthiness of wooden aircraft, require evidence to show that exceptional measures have been taken to ensure that such aircraft have been dismantled or opened up, and the upholstery removed to an extent to ensure that all defective timber and glued joints have been made good.

Flying a Weightless Parabola

THEORETICALLY, human reactions to weightlessness can be tested for periods up to half a minute in a jet aeroplane flying a parabolic course in a vertical plane, using just enough power to overcome air resistance. But in practice the feat has proved difficult, as ordinary *g*-meters are too insensitive.

In the *Journal of Aviation Medicine* (U.S.A.), Captain G. J. D. Schack and Major David G. Simons describe the results obtained with a much more sensitive instrument, the Statham accelerometer, which has a range of plus and minus 0.5 *g*. Two instruments were used, for registering both vertical and longitudinal accelerations. and their readings were made visible to the pilot by microammeters with a range of 25-0-25 m.amp.

The accelerometers were strapped to the chest of the particular human subject being experimented upon, as it was his accelerations, rather than those of the aeroplane, which mattered; he was also photographed.

Oscillograph recorders were installed for recording exact *g* values during the flights. Curiously enough, these showed that the pilots still found it extremely difficult to follow precisely a true weightless parabola, though they varied in skill individually. The longest consecutive period of zero-*g* obtained was no more than seven seconds, although values of less than 0.025 *g* could often be maintained for periods up to 22.5 seconds, and values of less than 0.1 *g* could be kept up for the full 30 seconds fairly easily.

But such small values of *g* were found to upset the engine. There was a loss of oil pressure due to the oil rising in the chamber, resulting in a loss of hydrostatic pressure at the oil sump at the bottom of the reservoir. Also, the trim-tab action was lost because of overheating of the trim-table actuator motor; this was attributed to loss of air currents, because convection is due to the differing weights of adjacent bodies of air, and disappears when none of the air has any weight.

One of the pilots taking part in these experiments, who previously had more than 3,000 flying hours, suffered from "extreme vertigo and disorientation" during weightlessness. Some such procedure as this will obviously be needed to weed out those unsuited to space flight.—A.E.S.

Ramjet on High

LAUNCHED from the R.A.E. rocket range at Aberporth, North Wales, an N.G.T.E./Napier ramjet test-vehicle has attained a height of 70,000 ft. in 40 sec.

Boosted at take-off by a cluster of eight solid-fuel rockets, the test-vehicle (of which a version was shown at Farnborough last September) reached a Mach number of 2.3. After fuel was exhausted the vehicle coasted on up to 114,000 ft. before it was destroyed, for safety reasons, by remote control.

The National Gas Turbine Establishment (N.G.T.E.) and D. Napier and Sons. Ltd., have worked together for some years in the development of ramjets and this test-vehicle is a later version of one which set up a height record two years ago. It is about 20 ft. long, 18 in. in diameter and burns kerosene.

John Boothman—The Last Tribute

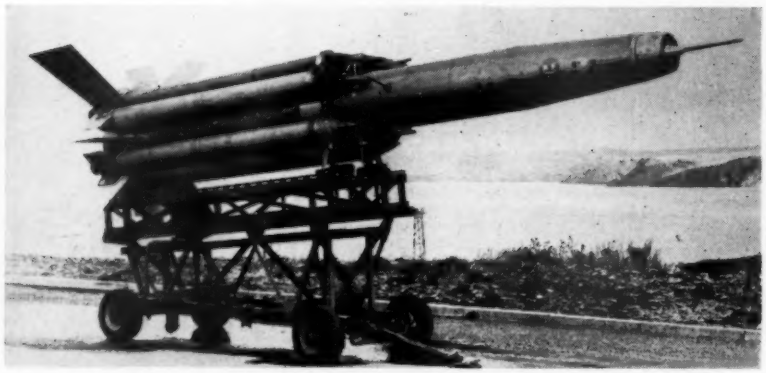
IN honour of the memory of "a truly great airman," as he was described by Marshal of the Royal Air Force, Sir John Slessor, who delivered the address, Christ Church, Down Street, London, was crowded to capacity for the memorial service on January 22 to Air Chief Marshal Sir John Nelson Boothman, K.C.B., K.B.E., D.F.C., A.F.C. Canon A. S. Giles (Chaplain-in-Chief, R.A.F.) officiated.

The Air Council and the R.A.F. were represented by Air Chief Marshal Sir Walter L. Dawson, Air Member for Supply and Organization, and Air Marshal Sir Geoffrey Tuttle, Deputy Chief of the Air Staff. Sir Geoffrey also represented Air Marshal C. E. Chilton, A.O.C., Malta.

The Secretary of State for Air, the Rt. Hon. George Ward, was represented by Sqn. Ldr. H. T. Murley, and Lady Boyle, wife of the Chief of the Air Staff, also attended. The Ministry of Supply was represented by Sir Cyril Musgrave, the Society of British Aircraft Constructors by its president, Mr. Cyril Uwins, the Royal Aeronautical Society by Major G. P. Bulman, the Guild of Air Pilots and Air Navigators, of which Sir John was a warden, by Sir Frederick Tymms and the Royal Aero Club by Mr. Kenneth Davies.

In the congregation were to be found the most distinguished personalities in the fields of Service life and of the Aircraft Industry in which John Boothman with his "unruffled efficiency," to quote Sir John Slessor again, had earned so much distinction. The dark-eyed boy who made his first flight with Cody has left behind to those that follow after a proud record and a happy memory.

NEWS OF AIRCRAFT, ENGINES AND MISSILES



RECORD RAMJET.—As recorded on page 129, an N.G.T.E./Napier ramjet test vehicle of the type shown here was recently fired from Aberporth to reach a height of 114,000 ft., where it was destroyed because it was by then nearing the range limit. Its "all-burnt" height was 70,000 ft.

A JAPANESE FIRST.—Powered by a Bristol Orpheus turbojet, the T1F2 produced by Fuji Heavy Industries, Ltd., flew for the first time on January 19. It was airborne for 27 min., piloted by Col. Takaoka, commander of the Experimental Air Unit, who took it up to 6,000 m.

"BACKFIN" IN THE AIR.—The Soviet supersonic bomber code-named "Backfin," an artist's impression of which was published in THE AEROPLANE for November 22, 1957, is now flying in prototype form.

AVON TIGER? — According to American reports, Grumman has offered to Western Germany a version of the F11F-1 Tiger powered by a Rolls-Royce Avon R.A.24 turbojet, which has a thrust of 11,250 lb., instead of the normal G.E.J79 powerplant. The new R.B.133 engine could replace the R.A.24 at a later date.

FLAPPING IN RUSSIA. — Reports from Russia indicate that several new ornithopters have been produced by Soviet aircraft designers. It is stated that "with a lifting power three to four times greater than that of conventional aircraft, they can take off and land at any place and can hover. . . . The ornithopters are fitted with different types of wings. Pavel Smirnov, for instance, has built a machine with wings resembling those of a bird, while Herman Rybnikov's machine has wings resembling those of an insect."

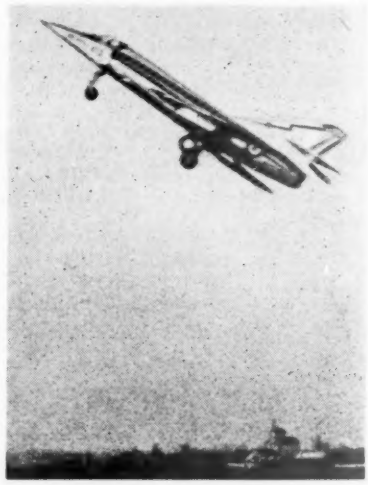
EXECUTIVE AMPHIBIAN.—The new Piaggio P.166 executive aircraft developed from the P.136L amphibian, began its flight trials recently for Italian and American certification. It has been built on the recommendation of the Trecker Aircraft Corpn., of America, which builds the P.136 under licence as the Royal Gull.

SPARROW PROGRESS.—A team of R.C.A.F. and Avro Aircraft personnel with two CF-100s have arrived at the U.S. Naval Air Missile Test Center at Point Mugu, California, to make test firings of the Sparrow 2 air-to-air missiles. The team will spend six months at Mugu. Sparrow 2 missiles are intended for the Canadian Avro Aircraft Arrow.

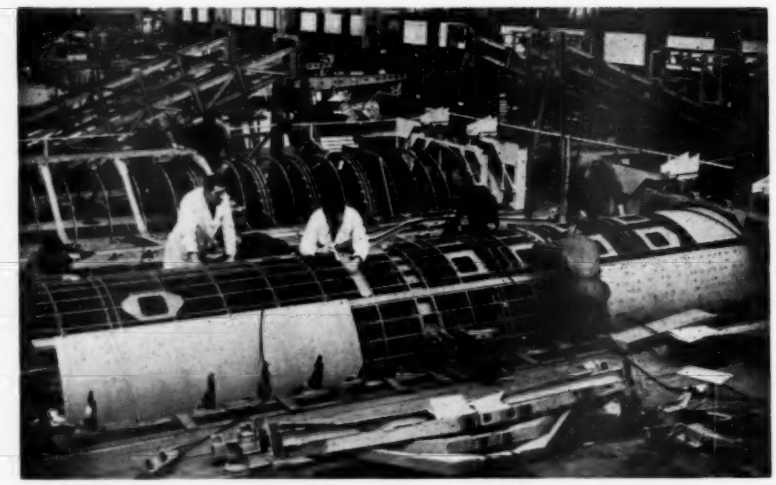
SERVICE WIDGEON.—As shown by the latest "D" Notice, the R.N. name for the Westland Widgeon is to be Dragonfly HR.7. The engine is an Alvis Leonides Mk. 70 with boost increased from 6½ to 8 p.s.i. for increased power at sea-level.

NEW GRUMMAN. — The Grumman Aircraft Engineering Corpn. of Long Island, N.Y., has won the recent U.S. Navy competition for a new attack aircraft. The aircraft is to be a two-seat carrier-based design for high- and low-level operation and will be jet-powered.

FAR EAST SIDEWINDERS.—The Japanese National Defence Agency has asked the Finance Ministry for 5.3 million yen with which to buy Philco Sidewinder air-to-air missiles.



BLOWN BOOST.—Take-off angle of the Dassault Etendard IV is steepened by the use of blown flaps. The system is claimed to give good stability at low speeds.



CANBERRA PRODUCTION.—The construction of the nose, wings and fuselage, etc., of the first production Canberra PR.9 is well advanced at Short Bros. and Harland. Major components of subsequent aircraft are taking shape. Shorts have built over 100 Canberras in the past seven years.

NEW AGUSTA PROJECTS.—Two indigenous helicopters are to be produced by the Italian Agusta company. The first, the Model 101D, is to be a 16-passenger design powered by three turbojets. The second is the Model 102, a seven-seater with a Pratt & Whitney piston engine. It is understood that the Italian Air Force is interested in the Model 101D for possible anti-submarine duties. Agusta builds the Bell 47 under licence.

HELICOPTER OVERHAUL. — The Bell Helicopter Corpn. of Fort Worth, Texas, has announced that the major-check periods for 47G and 47G-2 helicopters are now 1,200 hr.

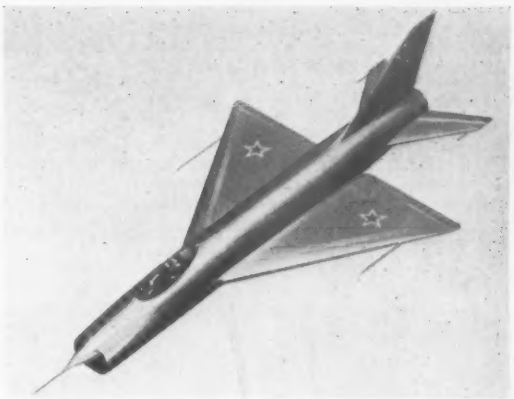
E.E.C. TAKE-OVER.—Hawker Aircraft's Squire Gate factory, where Hunter production recently ended, is to be taken over by the English Electric Co., Ltd., in March. With its Preston and Warton factories working on R.A.F. orders, English Electric would require the additional facility if any new orders were received. The former 4,000 people employed by Hawkers at Squire's Gate have been reduced to about 500 for aircraft maintenance.

WIZARD STOPPED. — Work on the Convair Wizard anti-missile weapon has been discontinued in favour of the Nike-Zeus. This was announced by W. M. Holaday, Director of Missiles at the Department of Defense, who said that Convair will not do any anti-missile work. Deputy Defense Secretary D. Quarles stated that the Bell Rascal air-to-surface weapon will become operational by April; and that ballistic missiles will be for many years to come at most a supplement to manned aircraft in the strategic striking force.

TARGET BOOM. — North American Aviation, Inc., of Los Angeles, has developed a new device which allows targets to be towed at speeds above Mach 1. Known as the centre-line tow target boom, the gear is 10 ft. long with a 2-in. diameter and is made of chrome-molybdenum alloy steel. It can be quickly installed and retracts against the underside of the aircraft. In operation it swings down through a 60° angle to snatch the target rope.

LIGHTWEIGHT ROTARY.—This single-seat helicopter, powered by a 105-h.p. engine was designed by Bodo Franke, formerly of Messerschmitts, who is seen in the cockpit. It does about 95 m.p.h. and uses 5 gal. an hour.

'FISHPOT' IN SERVICE.—This U.S. Navy photograph shows a model of the all-weather fighter designed by Sukhoi and code-named 'Fishpot' by NATO, which is reported to be in production in the U.S.S.R. Powered by a 22,000-lb. thrust turbojet, it has a maximum speed in excess of Mach 2. Formations of these aircraft have been seen in the Moscow area. The prototypes were first seen at Tushino in 1956. Approximate dimensions: span, 25 ft., length 50 ft.; diameter of the tail pipe, 52 in.



OCCULT PARTNERS.—Latest version of the McDonnell Voodoo interceptor carries Douglas Genie air-to-air missiles which can be fitted with atomic warheads.

FAST PENNANT.—Piloted by Lt. Pierre Galland, a Dassault Etendard IV set up (subject to confirmation) a new record of 1,020 km.p.h. (634 m.p.h.) over a 1,000-km. course on January 18 between Istres and Cazaux. The attempt was observed from the air by officials of the Aéro-Club de France.

MATADORS ON FORMOSA. — A U.S.A.F. squadron of ground-to-ground Matadors, a subsonic weapon capable of carrying an atomic warhead over a range of 500 to 700 miles, is now established for operational use on Formosa. Matadors launched from Formosa could hit Chinese Communist targets from Canton to Shanghai, and as far inland as Nanking.

S-R.177 REJECTED.—The proposal by Saunders-Roe that work should go on to build three S-R.177s for research purposes has been rejected by the M.o.S. Reorganization and replanning by the company has reduced the original estimated dismissal figure of 1,000 employees to 600.

NEW FIAT.—Developed from the Fiat G.91, the G.91A will have automatically-opening slats at the wing leading edges, and a 180-litre (40-gal.) integral fuel tank in each wing. These modifications increase the weight by 400 kg. (882 lb.) of which 300 kg. is extra fuel. Range is increased by about 10% and take-off distance reduced by about 25%.

COMMERCIAL AVIATION AFFAIRS

GATWICK OPENING.—H.M. The Queen will perform the opening ceremony for the new Gatwick airport on June 9. On that date B.E.A. will transfer the base for all its Channel Islands services to Gatwick.

BRITANNIA REGULARITY. — During the first three weeks of operation on the Aeronaves route from Mexico City to New York, the Bristol Britannia has achieved excellent regularity and serviceability. All flying has been concentrated on the second aircraft, XA-MED. Best flying times recorded were 5 hr. 8 min. to New York and 6 hr. from New York. Between December 18 and January 6 inclusive, this aircraft flew a total of 197 hr. 41 min. for an average daily utilization of just under 10 hr. In this period, no flight departure was delayed by aircraft or engine snags—except one cancellation when an improperly serviced toilet cap resulted in damage to a propeller.

AIRVIEWS EXPAND. — Using a Dove, Airviews, Ltd., have opened a four-times-weekly service between Manchester and Newcastle.

ROYAL FLIGHT. — H.M. Queen Elizabeth The Queen Mother was due to leave on Tuesday, January 28, for her visit to Australia and New Zealand. She was flying to Fiji in a B.O.A.C. DC-7C commanded successively by Captains J. Woodman (to Montreal), B. C. Frost (to Honolulu) and W. J. Craig. From Nandi, Fiji, she was due to complete her journey in a B.O.A.C. Britannia, commanded by Capt. R. C. Flower, reaching New Zealand tomorrow, Saturday.

880s FOR CAPITAL?—According to reports from Washington last week-end, Capital Airlines are to place an order for 15 Convair 880 turbojet transports to be delivered towards the end of 1960. If this order is confirmed it will bring the total number of 880 sales up to 63, the list being headed by T.W.A. with an order for 30.

FRIENDSHIP DELAYED.—*Aviation Daily* reports that the first Fairchild F-27 Friendship will not now be rolled out before the end of February. Original roll-out was scheduled for October, 1957; last August a revised target of December, 1957, was announced.

C.S.A. TO BRAZIL.—An unconfirmed Press report from Czechoslovakia says that C.S.A., the State airline, is planning to open a route to Brazil via Lisbon and Dakar, using Avia Il-14s. To operate such a route—the South Atlantic crossing from Dakar is 1,875 miles—the twin-engined Il-14s would need to carry extra fuel tanks and would have a very poor payload. The use of Tu-104As, of which C.S.A. has three, would seem to be more practicable.

LLOYD LIQUIDATION.—The Superintendent of Stock Companies in Colombia has ordered the liquidation of Lloyd Aereo Colombiano. The company's property has been confiscated in order to pay its creditors.

EDINBURGH-I.o.M. — The Northern Division of Silver City Airways will begin regular passenger service between Edinburgh and the Isle of Man on June 1. The service will be operated by Herons or Bristol 170s and will function on Fridays and Sundays.

WASHINGTON'S NEW AIRPORT.—President Eisenhower has agreed to a site at Chantilly, Virginia, for the new Washington Airport on which work will be started immediately. Chantilly is about 20 miles west of the U.S. capital, whereas the present, overloaded, Washington National is about two miles south of the city.

SELLING THE A.W.650. — Three senior executives of Sir W. G. Armstrong Whitworth Aircraft, Ltd., are at present in New Zealand to discuss the A.W.650 turboprop freighter with prospective customers. The team comprises Mr. C. S. Amery, sales director; Mr. D. A. Woodley, assistant chief designer (technical), and Mr. Alan H. Stratford, civil aircraft adviser. They will visit Australia before returning to this country in mid-February.

UNSCHEDULED SAFETY. — The C.A.B. has reported that U.S. unscheduled carriers have completed their second successive year of fatality-free operations.

ACCIDENT THEORY.—During the Court of Inquiry into the loss of P.A.A.'s Stratocruiser in the Pacific last November it was suggested that carbon monoxide may have overcome the crew. Medical evidence supported this theory, which would also explain the fact that no radio message was received from the aircraft to indicate an emergency.

A.R.B. NOTICES.—The Council of the Air Registration Board announces the issue of the following Notices to Licensed Aircraft Engineers and to Owners of Civil Aircraft: Contents List. Issue 20; No. 2 Issue 12; No. 4. Issue 22; No. 7. Issue 21. All are dated January 1, 1958.

J.A.L. PURCHASE.—Japan Air Lines has arranged to buy two DC-4s from P.A.A. for use on internal services.

VOTING POWER.—In a bid to gain control of Butler Air Transport, Ansett recently flew more than 500 shareholders to attend a meeting in Sydney. Butler countered with a similar move. The meeting had to be adjourned because of a legal difficulty.

NEWS ABOUT PEOPLE

AIR-RACE WINNERS.—Second from the left is Fred Dunkerley who with Flt. Lt. Brian Iles (extreme right) was honoured at the R.Ae.C. on January 21. With them here are left, Cyril Gregory, and James Denyer. The dinner is reported on page 156.

BRISTOL SERVICE.—Mr. J. Y. Tomlinson has been appointed chief service engineer (turbine engines) at Bristol Aero-Engines, Ltd. Mr. A. M. Chittenden has become chief service engineer (piston engines), and Mr. E. G. Pippin, chief service engineer (repair).

THE P. R. STORY.—Mr. Duncan Sandys, Minister of Defence, was among the distinguished guests who attended a cocktail party to mark the publication of "Evidence in Camera." He is seen here with the authoress, Miss C. Babington Smith, whose column over the pen name "Babs" was a feature of THE AEROPLANE before the War. Her book, the story of photographic intelligence during the War 1939-45, will be the subject of Sir Robert Saundby's article for February.

COLLEGE APPOINTMENT. — Mr. Austin Geoffrey Smith, A.R.C.S., B.Sc., D.I.C., has been appointed to the Chair of Aircraft Propulsion at the College of Aeronautics, Cranfield. During the War he worked with Power Jets and was later principal scientific officer at the N.G.T.E. Since 1952 he has held the post of Reader in Applied Thermodynamics, with special reference to gas turbines, at Imperial College, London.

SHEFFIELD LECTURE.—Mr. Eric Mensforth, C.B.E., chairman of Westland Aircraft, Ltd., will deliver a lecture, "The Future of the Helicopter," to the Sheffield Section of the Institute of Transport on February 3. The meeting will be held in the Royal Victoria Hotel at 18.30 hrs.

SAAB LOSS. — The Saab test pilot Trygve Ekbom was killed on January 18 when the Saab-32 Lansen he was flying crashed at a military training aerodrome south-west of Linköping. He had been making diving tests with the aircraft at the time of the crash.

R.Ae.C. AWARDS. — The *Britannia Trophy* for 1957 has been awarded to Messrs. Michael Randrup and Walter Shirley for setting up the World's aeroplane height record of 70,310 ft. on August 28 in the Scorpion-Canberra. Mr. John Cunningham receives the *Geoffrey de Havilland Trophy* for setting up the London-Khartoum point-to-point record of 523 m.p.h. in a Comet 3 on October 16.

A *R.Ae.C. Silver Medal* goes to Wg. Cdr. C. E. F. Arthur, C.F.I. of the Fair Oaks Aero Club, on completing 40 years of flying; he has flown 12,600 hr. on 105 different types. A *Silver Medal* also goes to Lt.-Col. A. J. Deane-Drummond, for a series of U.K. gliding records, including the winning of the National Championships. Capt. E. E. Fresson also receives a *Silver Medal*, awarded for his 40 years of flying, pioneering Scottish air and ambulance services. He has saved many lives by his flying and still holds a current C.P.L.

Mr. Harry Harper, for his work in connection with aeronautical journalism from 1906 to the present day, receives a *R.Ae.C. Bronze Medal*.

DR. RUDOLF HEBERLEIN.—We regret to record the death of Dr. Rudolf Heberlein, chairman of Swissair since 1951. He was 57.

MILITARY AVIATION AFFAIRS

GERMAN P.1 TESTS.—Two West German Air Force pilots, Col. A. Werner and Capt. H. Knierer, were to go to Warton last Monday to fly the English Electric P.1. Although the West German Ministry has already said that its Air Force is no longer interested in buying P.1s, reliable sources in Bonn are reported to have said that this visit implies that the fighter is again under consideration. Other aircraft under consideration are the Lockheed F-104 Starfighter, the Grumman F11F Tiger and the Dassault Mirage III.

DUTCH SEA HAWKS.—The last of 22 Sea Hawks built by Armstrong Whitworth Aircraft for the Royal Netherlands Navy under the U.S. Off-shore Procurement Programme was handed over at Bitteswell on January 23. The order was completed one month ahead of schedule.

SWISS HUNTERS. — The military committee of the Lower House of the Swiss Federal Parliament has voted 16 to 1 in favour of buying 100 Hawker Hunters for £26 million. Final agreement to the purchase by the Lower House is expected soon; the Upper House approved the order last December.

JAPANESE SABRES.—The first four North American F-86Ds of an order for 60 were delivered to Japan on January 16

A Guided-flight Lecture

MR. BEDFORD began his paper on "Guidance and Control" —read before the Guided Flight Section of the R.Ae.S. on January 23 (see page 128 of this issue)—by saying that he would include the intermediate step, called navigation, where the information from the guidance system was transformed into a control command that would give a manœuvre.

There were four present methods of guidance—by beam riding; command; homing, either active or passive; and inertial. There were two methods of control—aerodynamic by moving surfaces; and jet control.

He traced the seed of the beam-riding system to a proposal made in the 1914-1918 War by Puckle, that a weapon should be made to ride up the beam of a searchlight to deal with night raiders. He said that the proposal was sound; searchlights could often follow a raider continuously and yet the anti-aircraft guns often failed to hit it. Nevertheless the proposal was not followed up, perhaps because of the immaturity of the technical methods and partly perhaps the "comparative immaturity of Puckle, who was 17 years old."

In the past War, Mr. Bedford said, he proposed a beam-riding weapon which was called "Grapevine," and though progress was made, it was not ready before the War ended. This was a new development; radar which had first been used for the location of the target was now to be used first to find the target and then also to control the missile.

The missile was designed to be used with a conventional conical-scan ground radar. The principle of the system is shown in Fig. 1. The transmitter lobe is offset from the axis of rotation by an angle σ, known as the split angle, so that the signal strength on the axis A (and also the reflections from a target on the axis, for a detection radar) were uniform as regards cyclic strength; while the signal strength at a point T_2 would vary as the rotation of the lobe caused the angle ϵ between the lobe axis and the axis through T_2 to vary.

Variation of the signal showed that the receiver was off the beam centre, but did not give the direction unless the angle of rotation of the transmitting aerial was known simultaneously. In a missile receiver, this information could be found by detecting the polarization of the transmitter beam; as this polarization rotated at twice the aerial rotational frequency, the angular position of the transmitting aerial was established with an ambiguity of 180°. This ambiguity could be resolved on the ground before firing provided that continuous reception was maintained thereafter.

During the process of development they found that rotation of the missile on its own axis did not affect the working of the control, the axis was sorted out in the brain and correct directional control was operated; so that it was not necessary to stabilize the missile in roll.

Colonel Sedgfield, as he then was, developed a simulator for this guided weapon, a remarkable and original effort, and with this he showed that the twist and steer system of control seemed to be unsuitable for a beam rider. Such a missile was shown to have an inclination to ride with the beam axis either "above" or "below" the wings, so that a twist and steer missile with the former tendency would pitch up slightly and the beam axis would be brought to coincide with, and then probably pass "below," the missile axis. The missile would then roll through 180° to put the beam axis "above" again and then the process would be repeated so that there was a tiresome amount of unnecessary manœuvre with the twist and steer arrangement.

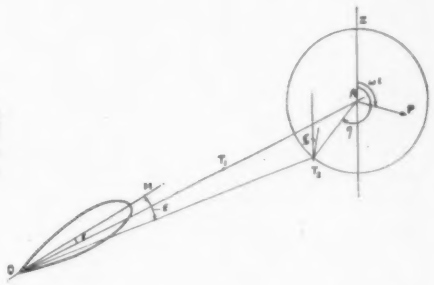


Fig. 1. The principle of the beam-riding system.

Two limitations followed from the nature of the beam-riding system. As the guidance was angular, the miss distance increased with range which was, therefore, limited. The second limitation was the shape of the track of the missile. The missile must always be on the beam from the radar to the target and Mr. Bedford showed a slide illustrating the form of its track for engagements at 37 kiloyards range and 30 kilofeet altitude at two missile and target relative speeds, and also the tracks for shorter ranges. These showed the tendency of the track to be curved so that the missile remains in the lower, denser, layers of the atmosphere and more propulsive power is required.

This last disadvantage could be avoided by using a riding beam with a programmed vertical angle; the missile would ride up this beam, which was set to lead it on a higher, more favourable, path, while another beam tracked the target; two radars per missile were needed instead of one, and some form of computer to lay down a programme which would give an economic path and then bring the missile onto the target beam.

Mr. Bedford said that the final method of guidance, inertial, at first appeared to him, on considering the performance available in gyros and in accelerometers, to be absurd, though theoretically capable of navigating a missile to a ground target of known position; for it would need instruments of extraordinary accuracy followed by double integration of their readings of the same order of accuracy. And a fixed reference direction is necessary for the three-dimensional system which would be a stabilized platform whose digressions must be reduced to a limit which seemed unattainable.

However, Minneapolis-Honeywell had produced the miniature gyro illustrated in Fig. 2, whose weight was half a pound, diameter 1.83 inches, length 2.77 inches, and whose angular momentum was 10^5 gram.cm.^{2}/sec. Its random drift rate at fixed torques was 1° per hour and its proportional acceleration drift was 1° per hour per g. Its total random drift after warm-up and compensation, under laboratory conditions, was 0.05° per hour. He said that this might be thought to be worth its weight in gold, but the manufacturers would hold that you were in error by a factor of 10!

There were three types of accelerometers, the usual type, another type giving a time-integrated acceleration and a third, still more advanced. The sensitivity here had to be of a similar order, with a bias error limited to 2×10^{-4} g.

More of Mr. Bedford's lecture, including his discussion of other guidance systems, will be summarized next week.—

KENTIGERN.

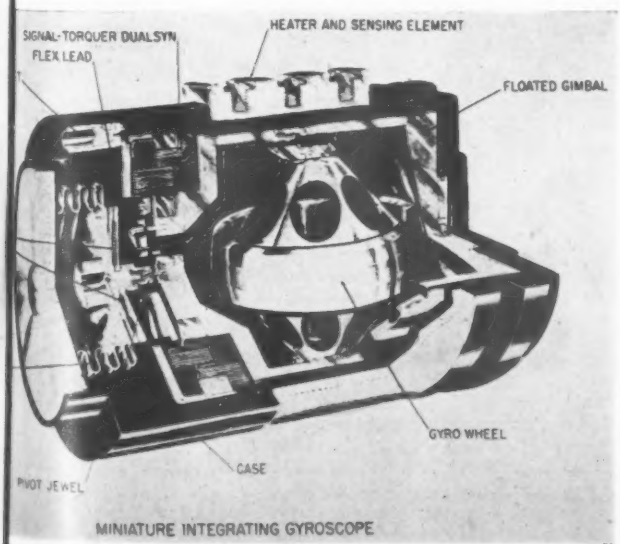


Fig. 2.

AIR TRANSPORT

Caravelles for Finland

THREE Sud-Aviation Caravelles have been ordered by Aero O-Y Finnair, for delivery in February, March and April, 1960. The contract was signed in Paris on January 18. Finnair will use the Caravelles on their network of routes within Europe, and probably that linking Helsinki and Moscow. The company's present fleet consists of 10 DC-3s and five assorted Convairs.

The order for Caravelles is another big step forward for Finnair, which has been expanding rapidly since Convairs were first acquired in 1953. A considerable proportion of the total Finnair traffic—some recent statistics are on page 136—is produced on its internal routes, from which the DC-3s will probably be gradually withdrawn and replaced by Convairs from 1960 onwards.

Sud-Aviation now have firm orders for 23 Caravelles, together with options on another 37. These orders are from Air France, 12 and an option on 12; S.A.S., six and an option on 19; Varig, two and an option on three; and Finnair, three and an option on three. Several other operators have shown positive interest in the Caravelle, among them T.A.A., who propose to buy two, and S.A.A.

Production of the Caravelle is extensively sub-contracted, with final assembly at the Toulouse Saint-Martin works. A static-test specimen and a fatigue-test fuselage have been completed and moved to the Etablissement Aéronautique de Toulouse (E.A.T.) for testing. The first production aircraft, for Air France, will fly soon, and the second for Air France and first for S.A.S. are in final assembly. Deliveries to Air France are scheduled to begin in December, 1958 and to S.A.S. at the beginning of 1959.

A production rate of not less than four Caravelles a month is planned by May, 1960, and this could be as high as seven a month, using the existing production facilities, if orders justified.

One of the two Caravelle prototypes should by now have left for Sweden to undergo cold-weather trials.

T.A.A. Viscount Developments

TRANS-AUSTRALIA AIRLINES will take delivery of their final two Viscounts in June and July this year, and at about the same time will embark on a modification programme on their existing fleet of eleven aircraft of this type. The first seven Viscounts delivered to T.A.A. (one was subsequently destroyed in a training accident) were of the 720 type, with Dart 506 (R.Da.3) engines; later re-orders, totalling seven more aircraft, were for the 756 type, with Dart 510 (R.Da.6) engines, and it is the last two aircraft of these orders which are soon to be delivered.

Compared with the earlier T.A.A. aircraft, these last two 756s —which the operator (but not Vickers-Armstrongs) is calling Super Viscounts—have two important modifications. One is to the wing structure, permitting an increase in gross weight from 63,000 lb. to 64,500 lb., the highest at which the Viscount 700D Series has yet been cleared; the other is to introduce the long-stroke (14-in.) undercarriage, with tyre pressures reduced from 110 p.s.i. to 85 p.s.i.

The new all-up weight permits an increase in payload with full tanks of some 1,200 lb., representing six passengers on the long Adelaide-Perth run. The reduction in tyre pressure will make it possible to operate the Viscount at various airports in Australia where it cannot be used at the moment.

An intensive modification programme is to be undertaken by T.A.A. to convert all their Viscounts to approximately the latest standard, with Dart 510 engines and the long-stroke undercarriage with low-pressure wheels. Only selected aircraft will be modified for operation at 64,500 lb., however, as the wing structure of the earlier aircraft, designed for a gross weight of 60,000 lb., cannot easily be altered in this particular respect. The landing weight of the fully-modified 756 is 57,500 lb., and the zero-fuel weight, 50,000 lb.

880 STYLING.—This first illustration of the fully finished mock-up of the 880 shows the Convair-designed styling for a four-abreast layout. Features of interest are the twin windows at each seat row, ventilation grilles in the wall, and overhead passenger service panels.

Precautionary Modifications

TWENTY-ONE Viscounts of the earliest series were withdrawn from service with three airlines last week-end to permit modifications to be made to the wing spar booms. This action, taken at the joint request of the makers and the A.R.B., followed the discovery of some small fatigue cracks around the edges of some of the bolt holes in the spar. B.E.A. withdrew 10 Viscount 701s from service, Air France withdrew nine Viscount 708s and Aer Lingus withdrew two 707s.

The part of the structure affected is the spar boom in the inner wing, and only the aircraft with the earliest type of boom, fabricated in DTD 363A, are involved. This original boom was used in the first 36 Viscounts, and the 21 aircraft which are now being modified are all from this batch.

A safe life had been established for these booms—from the fatigue scatter patterns built up from strain-range recorders carried in many Viscounts—and as these lifes were reached, the operators were modifying the aircraft. Several of the Viscounts concerned had already been modified in this way over the past year or so; others of the original batch of 36 have stainless-steel bushes in the skin-attachment bolt holes and do not need modification. Later aircraft were produced from the outset with DTD 363A spar booms with these bushes and of modified section, or with L65 booms, which are the present standard, with a safe life of 20,000 landings.

The booms replaced in the modification programme were returned to Vickers for examination and continued testing, and it is as a result of these tests that the safe life has been re-assessed and the decision taken to complete the modifications immediately.

Co-ordinating U.S. Air Traffic Control

SPEAKING at a recent computer conference in Washington, Mr. E. R. Quesada, chairman of the Airways Modernization Board, said that the United States was "on the eve of embarking on the most comprehensive use of automatic data processing for air traffic control that has yet been attempted."

The Board, which was authorized by Congress last August, and is a joint civil-military research organization, will concentrate on improving five major features in air traffic control—data processing, airport design, communications, navigation, and ground position-determination of aircraft. Existing research and development will be integrated by the Board.

"The application of machine computation to the processing and display of A.T.C. information will," Mr. Quesada said at the conference, "be the first problem to be considered." The Board has asked the electronics industry to submit proposals for a programme using automatic data processing techniques for the New York A.T.C. centre.

Independent Consolidation

THE steady consolidation of the British independent operators into a smaller series of stronger units has made further progress with the acquisition by Airwork of a "substantial interest" in the air transport and engineering group of companies headed by Mr. F. A. Laker. This new development was announced last week.

The main companies in the Laker group are Air Charter, which operates vehicle-ferry and trooping services from Southend and freighting and contract operations from Stansted, and Aviation Traders (Engineering), which has developed, at Southend and Stansted, a production, development and design organization. The Air Charter organization will continue to operate as a self-contained unit; the eventual status of the engineering side of the business is not yet finally decided.

Among the activities of Aviation Traders has been the design and development of the turboprop Accountant short-medium-stage transport aircraft, the prototype of which flew for the first time on July 9, 1957. No production arrangements had been made for this aircraft and the prototype, G-ATEL, is being stored. Airwork state that they have no plans at present for its future.

Airwork's other subsidiaries and associates are Transair, now at Croydon and due to move to Gatwick, and Fison-Airwork, which specializes in agricultural aviation work.

Vanguard Progress

TARGET date for the first flight of the Vickers Vanguard is November 1, 1958, according to a progress report issued by Vickers-Armstrongs (Aircraft), Ltd., recently. This report, which is largely pictorial, shows that at the end of December, 1957, 81% of the total number of drawings had been completed —some 26,000 out of the total 32,000. Primary structure drawings were completed on April 10, 1957.

Tooling is also well advanced, with 98% of the jig and tool design completed and 82% of the actual jigs and tools completed by the end of last year. The first set of production tools was to be completed before the end of this month.

In the Vanguard erecting shop at Weybridge—where production of the Valiant has recently been completed—the first fuselage is now in one piece and the centre front and rear fuselage sections of the second Vanguard are nearing the point where they will be joined. As the fuselages move down the shop, two parallel final assembly lines will eventually be established, for the joining of wings and fuselages, addition of powerplant and tail unit, and so on.

Five aircraft are to be used in the Vanguard certification programme, which is planned to take 1,600 hours. These will comprise the first prototype and the first four B.E.A. aircraft, which will join the programme, it is planned, in January, March, June and September, 1959, respectively. A limited C. of A. is expected by the middle of 1959 and the full certification target date is March, 1960.

B.E.A.'s Best Year

AS we recorded briefly in last week's issue (p. 100) B.E.A. has, according to preliminary estimates, returned a net profit, after deduction of finance changes, of £1,200,000 for the calendar year 1957.

The fact that such a good result has been achieved over the calendar year does not necessarily mean that quite the same high figure will be returned for the financial year, but the net figure for this period should be better than £1 million.

	Year ended December 31 1957	Year ended December 31 1956	Variation
Capacity ton-miles offered ..	156,229,000	138,254,000	+13.0%
Load ton-miles sold	101,000,000	87,943,000	+14.8%
Revenue load factor	64.6%	63.6%	+ 1.6%
Passengers carried	2,752,000	2,436,000	+13.0%
Passenger-miles flown ..	926,010,000	794,781,000	+16.5%
Passenger load factor ..	70.3%	69.3%	+ 1.4%
Freight ton-miles	9,747,000	8,840,000	+10.3%
Mail ton-miles	3,593,000	3,593,000	—
Average staff numbers ..	10,848	10,374	+ 4.6%
C.T.M. per employee ..	14,400	13,300	+ 8.3%

The figures in the table show the main features of the traffic and other results for the calendar year and it will be seen that there has been a considerable improvement in the output per employee—which, in 1957, was the highest figure ever reached by the Corporation. In his comments on the results, Lord Douglas says that this figure is the "key" to the good financial results.

There has also been an all-round saving in expenditure and Lord Douglas remarked about the situation in November, when the revenue was £50,000 short of the budget expectation and yet a similar saving in expenditure left the results for this month exactly as planned.

Decca in the United States

FOR more than two years the hope has been expressed that the Decca Navigator system might find an entry into the United States through the specific, local-service requirements of New York Airways, the helicopter operators.

Now, at last, a chain is to be laid down in the New York area for evaluation by N.Y.A. The U.S. licensees of the Decca

Navigator Company, Bendix-Pacific, have received a contract for the installation and operation of a chain the coverage of which will be approximately as shown in the map above.

This contract has been placed by the Air Modernization Board, the chairman of which is General E. R. Quesada, and N.Y.A. will, when the chain is ready, carry Flight Log equipment on all scheduled operations. General Quesada has, it is reported, stressed the fact that Decca has been chosen because it is the only system which is in a state of operational readiness for such uses.

The New York chain should be in operation by April 1. The "hard" coverage, as will be seen from the map, takes in Boston and Philadelphia.

The Corporations Come to Terms

AFTER many years of difficulty over the inevitable overlapping of the services of B.O.A.C. and B.E.A. in Europe and towards the Middle East, the two Corporations have now reached a firm agreement.

B.O.A.C. is now free, after consultations with B.E.A., to operate through any point in Europe; B.E.A., in return, is to be permitted to extend its services to Beirut, Tel Aviv and Cairo and will also operate services to the Persian Gulf on behalf of Cyprus Airways. The terms of the new arrangement are given some prominence in the current editions of the *B.E.A. Magazine* and the *B.O.A.C. Review*.

The problem in the past has been simply that B.O.A.C., in order to compete with foreign airlines, has necessarily had to have traffic rights at major points in Europe and was, consequently, flying over some sectors in parallel with B.E.A. In order to meet this difficulty, the two Corporations have, in the past, used a revenue-pooling system for the operations over

common sectors. Nevertheless, B.O.A.C. was depriving B.E.A. of business within the latter's defined sphere of influence and B.E.A. naturally resisted the approval to B.O.A.C. of additional points of call in Europe, or of increases in the frequency of the parallel services—and this resistance hampered B.O.A.C. in the expansion of its traffic in and out of Europe.

In effect the recent agreement means that B.E.A. has accepted the need for B.O.A.C.'s traffic-stop freedom in Europe (subject to foreign approvals) in exchange for an equivalent amount of work outside its own agreed territory—and the Middle East has been an obvious area for such expansion.

Eire's Atlantic Hopes

PLANS which are now being made in Eire to establish the Irish flag over the Atlantic are a revival of a 10-year-old dream. The idea, as we have recorded, is for Aer Rianta, or a subsidiary company, to hire Super Constellations from Seaboard and Western Airlines, the U.S. operator.

With these aircraft, to be hired on a mileage basis, a service will be operated between New York and Shannon, with a frequency varying from three to seven times a week. If traffic demands, the aircraft will fly on to Dublin, technically on charter to Aer Lingus. It seems that the Eireann Government is anxious not to establish Dublin as an Atlantic terminal.

Aer Rianta, the national company which holds 90% of Aer Lingus shares, formed another subsidiary, Aerlinte Eireann, in 1947 to operate an Atlantic service. Five L-749A Constellations were purchased for this purpose, but in February, 1948, the plans were abandoned and the aircraft were sold—to B.O.A.C.

The name Aerlinte will again be used if the present plans are fulfilled. Seaboard and Western, which has no regular passenger schedules but has a wealth of Atlantic experience as a result of its scheduled freight service and general charter flying, will invest in a small way in Aerlinte, and will presumably provide the crews as well as the aircraft. The agreement between the Eireann Government and Seaboard and Western is for an initial period of two years.

European Traffic Trends

STATISTICS, it is said all too often, can be made to prove anything. In presenting here the first set of statistics in a series which, it is planned, will be a regular quarterly feature, we are not setting out to prove anything. Our aim, rather, is to place on record the principal operating results of individual airlines each quarter, to show how these results compare with those achieved in the same quarter a year earlier, and to show the overall traffic trends.

To obtain these figures, we invited the co-operation of the major airlines operating scheduled services in Europe, both domestically in their own countries, and internationally. One or two of these operators have felt unable to supply the information, but that contained in the table is of considerable interest in showing the affairs of nine airlines individually, and is sufficient to show also the total pattern.

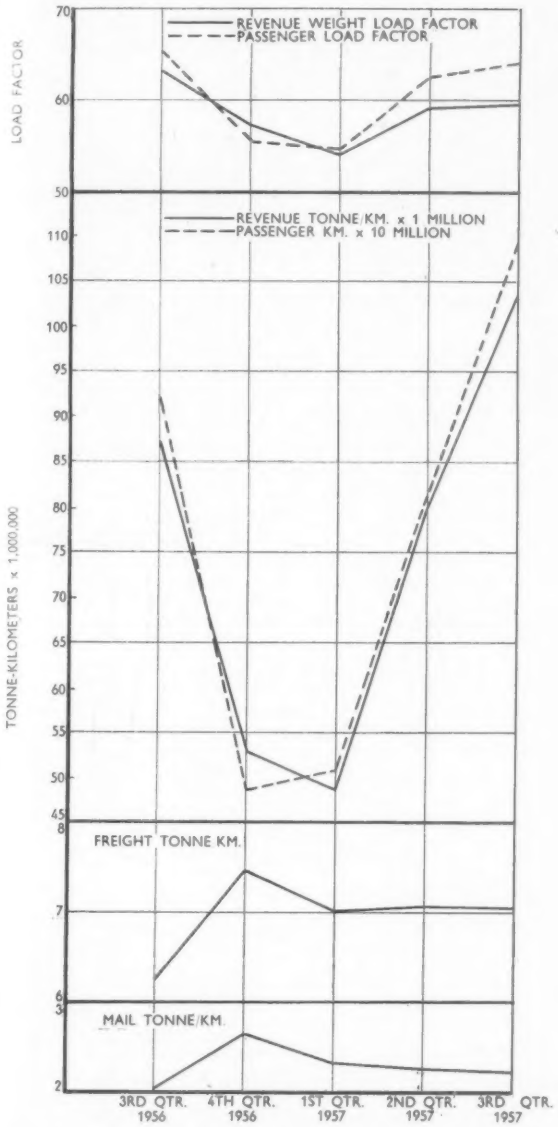
The curves (opposite) have been drawn for the total results of these nine operators to show mail, freight and total revenue tonne-kilometres, passenger-kilometres and passenger and total revenue load factors in the period from July-September, 1956 to July-September, 1957 inclusive. The specific values on these curves do not, it should be emphasized, represent the total of European traffic, but the shape of the curves is representative of the average trends.

The figures in the table are for the most part self-explanatory, and can be used as the basis for various calculations and deductions which our readers—or at least those professionally concerned—will probably wish to make for themselves. The final column of statistics for each airline, in which the result for the third quarter of 1957 is expressed as a percentage change of the result for the same quarter of 1956, is possibly the most interesting.

A study of these figures shows that Aer Lingus fared substantially less well than the other operators analysed; this can be attributed to the fact that they no longer have a

	3rd qtr. 1956	4th qtr. 1956	1st qtr. 1957	2nd qtr. 1957	3rd qtr. 1957	3rd qtrs. % change	3rd qtr. 1956	4th qtr. 1956	1st qtr. 1957	2nd qtr. 1957	3rd qtr. 1957	3rd qtrs. % change
	AER LINGUS						ALITALIA—L.A.I.					
Pass. carried	199,530	74,244	61,706	95,259	192,803	− 3.5	128,504	75,679	52,366	111,041	156,150	+21.9
Pass. L.F. %	78.8	63.5	65.4	69.5	74.9	—	67.7	57.9	46.0	62.9	66.3	—
Pass.-km. (1000)	73,915	28,191	22,898	36,450	74,998	+ 1.4	66,606	41,024	28,997	64,278	87,618	+31.5
Freight tonne-km.	400,102	450,628	354,802	397,518	395,952	− 1.1	601,560	647,957	528,946	670,609	707,766	+19.4
Mail tonne-km.	94,174	115,228	115,232	115,872	97,071	+ 3.2	195,376	215,713	196,747	237,804	270,333	+38.4
Total tonne-km. (1000)	6,515	2,903	2,371	3,519	6,613	+ 1.5	6,806	4,586	3,312	6,604	8,703	+27.9
Revenue L.F. %	72.6	66.8	67.0	65.8	67.2	—	68.0	61.6	49.8	61.6	63.5	—
	BRITISH EUROPEAN AIRWAYS						FINNAIR					
Pass. carried	961,271	432,120	391,319	759,252	1,096,035	+12.3	114,979	83,653	78,152	103,196	122,097	+ 6.2
Pass. L.F. %	75.0	66.9	66.4	71.8	75.5	—	65.5	50.8	47.2	74.5	58.4	—
Pass.-km. (1000)	492,900	232,331	215,644	408,775	580,364	+18.0	46,888	34,406	31,252	44,128	51,602	+10.3
Freight tonne-km.	3,100,793	3,622,925	3,310,846	3,472,548	3,363,894	+ 8.5	269,664	375,664	308,003	278,269	253,273	+ 6.6
Mail tonne-km.	1,114,894	1,583,740	1,228,856	1,185,724	1,139,980	+22.4	81,386	124,789	103,299	96,656	90,096	+11.1
Total tonne-km. (1000)	45,678	25,195	23,182	39,354	53,231	+16.5	4,388	3,451	3,072	4,149	4,702	+ 6.8
Revenue L.F. %	66.8	63.6	62.2	64.5	67.8	—	62.4	51.7	47.9	53.4	51.8	—
	IBERIA						LUFTHANSA					
Pass. carried	25,795	18,937	16,723	26,290	28,956	+11.5	34,843	30,757	30,297	48,897	59,179	+14.6
Pass. L.F. %	53.3	51.3	46.2	59.9	52.3	—	66.1	57.6	64.8	63.2	65.0	—
Pass.-km. (1000)	25,594	17,775	14,693	24,337	25,937	+ 1.37	21,582	19,398	17,963	26,503	31,277	+44.9
Freight tonne-km.	81,881	102,707	128,257	112,407	104,331	+27.6	136,722	198,743	140,026	178,341	215,400	+57.7
Mail tonne-km.	33,588	52,225	46,470	46,749	48,410	+45.4	62,968	69,362	64,568	77,098	94,000	+20.3
Total tonne-km. (1000)	2,472	1,809	1,537	2,318	2,544	+ 2.9	2,079	2,011	1,791	2,567	3,139	+52.6
Revenue L.F. %	54.7	58.9	51.3	56.9	53.7	—	56.7	48.0	53.4	55.4	58.0	—
	SABENA						SWISSAIR					
Pass. carried	116,019	67,002	70,059	127,675	162,175	+39.6	208,233	124,261	135,004	221,406	252,351	+21.8
Pass. L.F. %	63.1	45.8	43.7	56.9	61.2	—	67.5	59.0	55.4	62.8	66.2	—
Pass.-km. (1000)	59,456	41,444	41,680	73,618	90,230	+52.5	119,704	64,457	131,047	122,471	143,151	+19.2
Freight tonne-km.	964,819	1,290,884	1,157,986	1,051,660	1,147,165	+18.8	646,000	757,000	850,000	857,000	827,000	+28.1
Mail tonne-km.	136,202	176,388	207,599	167,976	156,616	+15.9	307,000	304,000	336,000	337,000	333,000	+ 8.5
Total tonne-km. (1000)	6,633	5,316	5,359	8,095	9,682	+48.2	11,864	6,938	7,824	12,246	14,088	+18.6
Revenue L.F. %	70.6	56.7	53.4	62.5	65.1	—	67.1	60.0	56.5	56.9	58.9	—
	T.A.P.											
Pass. carried	10,125	6,469	5,242	11,207	11,535	+13.9						
Pass. L.F. %	56.0	50.0	47.0	65.0	63.0	—						
Pass.-km. (1000)	9,083	5,380	4,632	9,745	9,948	+ 9.6						
Freight tonne-km.	50,320	31,977	32,290	54,295	47,889	− 5.0						
Mail tonne-km.	26,260	23,356	22,167	28,933	26,992	+ 2.67						
Total tonne-km. (1000)	902	544	475	968	979	+ 8.55						
Revenue L.F. %	50.0	47.0	45.0	57.0	53.0	—						

Note: These statistics are for the total European operations—i.e., domestic and international—of each airline. Those for Aer Lingus, B.E.A. and Lufthansa are scheduled operations only. Alitalia-L.A.I. freight tonne-km. include excess baggage and newspapers.



The total traffic of the nine operators covered by the tables alongside, is shown in the graphs above. The trends shown are typical of European operations as a whole.

monopoly of the London-Dublin route which accounts for a major proportion of their traffic. The Alitalia-L.A.I. statistics are complicated by the fact that the two airlines merged during the period reviewed, and the rate of change shown is not likely to be continued over the next twelve months.

Lufthansa continued to make great strides, as these figures show, and Sabena also showed, at 48.2%, a very high increase in total revenue tonne-kilometres performed. The traffic associated with winter sports in Switzerland gives Swissair an advantage over other operators in the first quarter of the year, which is the worst for all other operators except Sabena. More difficult to explain is the enormous jump in Iberia's mail and freight traffic. The size of Finnair operations may surprise some readers; approximately half the total revenue tonne-kilometres in this case are performed on domestic routes in Finland.

So far as the curves of total traffic are concerned these show the well-known peak-and-valley situation, with the accepted overall upward trend. The trough in passenger traffic is compensated a little by increased mail and freight around Christmas, but the problem continues to be of tremendous significance to the economics of every airline operating in Europe.

Revival in the North

SILVER CITY'S Northern Division is starting five new international services from the north of England during May this year. Four of these (with two domestic services) are to be operated from Newcastle upon Tyne, and one from Blackpool, where Customs facilities are to be provided at Squires Gate Airport as from May 1.

The services from Newcastle are, in effect, a continuation of those operated earlier by Dragon Airways for Hunting-Clan Air Transport. Dragon was taken over by the British Aviation Services group last summer, but there have since been delays in the granting of route licences.

The new international services are from Newcastle to Amsterdam (twice weekly), Dusseldorf (once weekly), Brussels, via Yeadon (twice weekly) and Hamburg (once weekly), and from Blackpool to Ostend (at the week-end). The new domestic services are from Newcastle to Blackpool and the Isle of Man. All these services will be operated with 36-seat DC-3s.

The Independents' Portion

THE comments on policy in the article on the background to the West African Safari service (last week's issue, pp. 105-106) were, we find, misleading in that the assumption was made that the 30% capacity ruling applied to the existing tourist service between London and Accra. In fact, the comments could fairly be applied to possible future services on this and on the Central African routes, but not to those at present operated.

In his statement on June 26, last year, the Minister of Transport and Civil Aviation said, in effect, that, following the introduction of so-called T.34, or third-class fares on the existing Nairobi, Salisbury and Accra services, Airwork and Hunting-Clan will be permitted to operate such services in place of the Colonial Coach services. The approval would be "on the basis of B.O.A.C. having 70% and Airwork and Hunting-Clan together having 30% of the U.K. share of the capacity needed for the new class of service."

These proportions were, the Minister stated on behalf of the A.T.A.C., about those "in which tourist plus Colonial Coach traffic is at present divided between B.O.A.C. and the independent companies."

The point, however, is that T.34 fares have not yet been introduced in Africa. Our comments were premature.

To Serve the Customer

VICKERS-ARMSTRONGS (AIRCRAFT), LTD., have announced a significant re-organization of their sales and associated technical teams, designed to give still more attention to the detailed requirements of overseas airlines. We described the Vickers civil aircraft development and sales organization in some detail in our issue for November 15, 1957. As a result of this re-organization, Mr. Derek J. Lambert has been appointed assistant general manager (development). He was previously chief development engineer (civil), with responsibility for the Civil Aircraft Development Group of the design office, and is probably the most-travelled of all Vickers executives.

Mr. D. J. Lambert.

Mr. Lambert will now, in effect, establish a new department in which he will be assisted by Mr. N. A. Barfield and Mr. C. Hamshaw-Thomas, appointed senior development assistants. To supervise the work of the C.A.D.G., Mr. J. N. Montgomery has been appointed senior development engineer and Mr. J. B. Armstrong is senior operations engineer in this group.

Both the new development department and the C.A.D.G. will continue to work closely with the sales department, under Mr. R. C. Handasyde, the sales manager. In his office, three area assistant sales managers have now been appointed—Mr. H. C. W. Sharp for the Middle and Far East, Mr. A. G. Page for Europe and Africa, and Mr. D. Sykes for North America.

Boeing's Growing Family

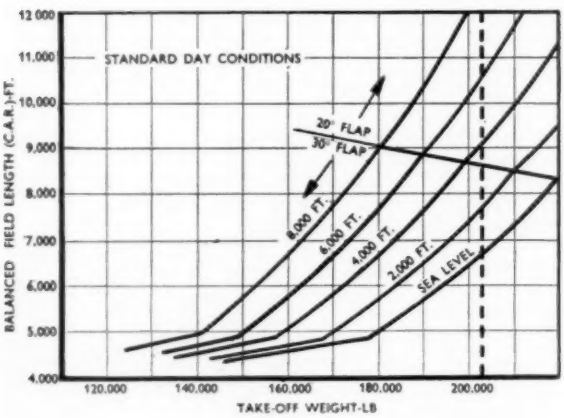
DEVELOPMENT of the Boeing 720 medium-haul turbojet transport, which was recently adopted by United Air Lines after a lengthy period of competitive evaluation, represents the second phase of the company's commercial jet transport programme. The first phase was the design and sale of the long- and very-long-range versions of the Boeing 707. Studies of medium- and short-haul turbojet designs to complement this range of aircraft began over two years ago, and led to the Boeing 717 project for medium ranges and the Boeing 727 for short ranges.

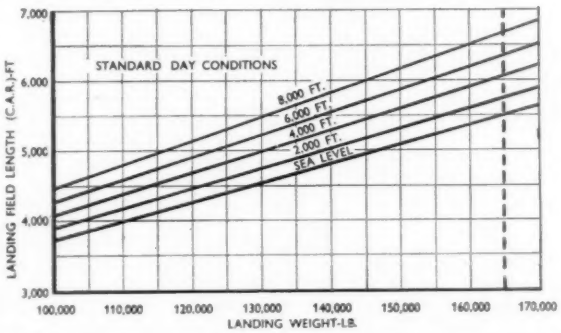
The Boeing 717 was further developed, principally to meet the United Air Lines requirement, into the Boeing 720, which is in fact no more than a lightweight version of the smallest 707 design. Weight has been saved by reducing the maximum design payload by 3,300 lb.; by reducing the basic fuel capacity by 2,820 Imp. gall.; by using lighter versions of the Pratt and Whitney JT-3C engines with a total saving of about 3,000 lb.; and by redesigning the undercarriage and airframe structure for the resultant maximum gross weight of 203,000 lb., which compares with the 707-120's 248,000 lb.

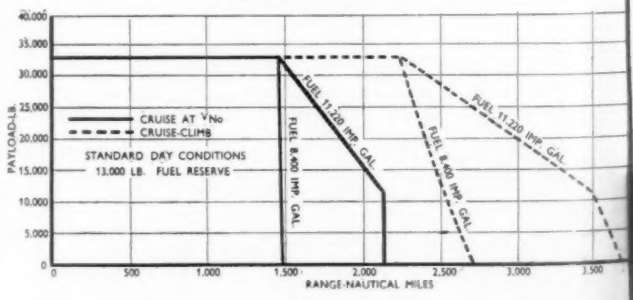
The sales appeal of the Boeing 720 derives from its particular combination of speed, payload, range and operating economics. Compared with the Convair 880, which is the smallest of the American turbojet transports announced to date, the Boeing 720 carries a significantly greater payload over a shorter distance; in other words, the dividing line between fuel and payload has been reassessed and, in the case of United at least, the Boeing division appears to be more in keeping with the requirements for an intermediate-stage aircraft. The initial United order is for 11 of these aircraft at a value of $39,700,000; there is also an option on 19 and the company's president has said his airline will want 50 Boeing 720s by 1965. Basic sales price is given by Boeing as $3,400,000; deliveries begin in April, 1960.

The maximum structural-limit weight of 203,000 lb. in the 720 allows for the design payload of 33,000 lb. and the basic fuel capacity of 8,400 Imp. gall. Space provision is made, however, for a max. tankage of 11,220 Imp. gall., which can be carried when the payload is reduced. No fuel is carried inboard of the landing gear support ribs, where optional tanks are located in the Boeing 707-120 and -220.

Payload-range, take-off and landing performance of the 720 are shown in the accompanying curves. The aeroplane is designed for operations by a flight crew of three and basic passenger capacities are 110 first-class or 130 tourist. Total cargo volume is 1,235 cu. ft. Some of the salient physical characteristics of the 720 are tabulated here, and compared with the newest Boeing figures for the 707 family; other data include: overall length 134 ft. 6 in.; internal cabin width 12 ft. 4 in.; wing sweep-back 35° at 25% chord; cruising speed over 600 m.p.h.; cruising altitudes 15,000 to 40,000 ft.







BOEING COMMERCIAL JET AIRLINER FAMILY

	Domestic	Domestic		Domestic	Overseas		Overseas	
Basic Model	Boeing 720	707-120		707-220	707-320		707-420	
Name	Seven-Twenty	Jet Stratoliner		Jet Stratoliner	Intercontinental		Intercontinental	
Power Plant	4 × JT-3C-7	4 × JT-3C-6		4 × JT-4A	4 × JT-4A		4 × Conway	
Wing Area Sq. Ft.	2,433	2,433		2,433	2,892		2,892	
Wing Span Ft.	130.8	130.8		130.8	142.4		142.4	
Max. Gross Weight Lb.	203,000	248,000		248,000	296,000		296,000	
Max. Landing Weight Lb.	165,000	175,000		175,000	195,000		195,000	
Fuel Capacity—Basic Imp. Gal.	8,400	11,220		11,220	17,650		17,650	
Fuel Capacity—With options Imp. Gal.	11,220	14,490		14,490	19,085		19,085	
Fuselage Length Ft.	128.8	128.8	138.8	138.8	138.8	145.5	138.8	145.5
Operating Weight Empty Lb.	103,145	111,082	113,640	117,400	129,143	131,364	127,679	129,900
Max. Design Payload Lb.	33,000	36,300	42,400	42,400	40,000	42,000	40,000	42,000
No. Passengers (1st Class)	110	106	121	121	121	131	121	131
Cargo Volume Cu. Ft.	1,235	1,235	1,600	1,600	1,500	1,700	1,500	1,700

NOTE: Fuel capacity, operating weight empty, maximum payload, number of passengers and cargo volume vary considerably between customers in accordance with customer option choices and master changes.

The three graphs show estimates of the Boeing 720's take-off performance (above, left), landing performance (top right) and payload-range characteristics (above). The payload-range curves assume still-air and I.S.A. conditions, and show the ranges with basic and optional extra tankage, using high-speed and cruise-climb techniques. The table on the left compares the characteristics of the Boeing 720 with those of other members of the Boeing family.

THE FIGHTING SERVICES

Senior R.A.F. Appointments

AIR COMMODORE G. A. M. KNIGHT, C.B.E., Principal Medical Officer, 2nd T.A.F., since September, 1956, is to become Deputy Director-General of the R.A.F. Medical Services at the Air Ministry in March, with the acting rank of Air Vice-Marshal. He will be succeeded in Germany by Gp. Capt. J. F. Dales, who has been on the staff of the Director-General at the Air Ministry since 1952. Prior to his present appointment Air Cdre. Knight was Deputy Director-General of Medical Services from June, 1955.

Group Captain J. H. Searby, D.S.O., D.F.C., has been appointed Director of Operations (Bomber and Reconnaissance) at the Air Ministry, with the acting rank of Air Cdre. Commanding R.A.F. Hemswell from 1953 to 1954, Gp. Capt. Searby attended a course of the National Defence College, Canada, in 1955, and became Group Captain Operations at Headquarters, Bomber Command, in January, 1957.

R.O.C. Recruiting

DURING the last quarter, ended December 31, 1957, the highest number of spare-time observers recruited for some time joined the Royal Observer Corps. Numbering 699, of whom 135 were women, these recruits have brought the total strength of the Corps up to nearly 16,000, of which 2,830 are in the Metropolitan, 3,505 in the Southern, 1,964 in the Eastern, 3,226 in the Western, 2,113 in the Northern and 2,276 in Scottish Areas.

Among the latest members of the Corps to be awarded the R.O.C. Medal, instituted in 1950 by King George VI for those completing 12 years' service, are 13 chief observers, four leading observers and eight observers.

R.A.F. Manston

AS one of a number of planned changes which have recently been made in the size and disposition of U.S.A.F. forces in the United Kingdom, including the reduction of U.S.A.F. requirements at R.A.F. Burtonwood and R.A.F. Sealand, the 406th Interceptor Wing and other American units are to be withdrawn from R.A.F. Manston by the middle of this year. A U.S.A.F. interceptor and fighter/bomber base for some years. Manston was integrated into the Fighter Command air-defence system in 1954, and is one of the master military and civil-diversion airfields in the south of England.

The Air Ministry is at present considering the future of the station, but it might well be selected as a Fighter Command base for English Electric P.1s. Consisting of one main runway of 3,000 yd., and equipped with FIDO, Manston is above the operational runway requirement of 2,500 yd. for the P.1 and could avoid the extension of an existing fighter station at present equipped with 2,000-yd. runways.

WINGS PRESENTED. As reviewing officer at the passing-out parade of No. 128 Provost/Vampire Course at No. 5 F.T.S., R.A.F. Oakington, on January 15, Air Vice-Marshal A. D. Gillmore, S.A.S.O., Home Command, presented the flying badge to his son, Plt. Off. J. M. Gillmore, on the completion of his course.

Recognition Contest Results

FOUR out of the six trophies competed for in the 11th Aircraft Recognition Contest organized by the Aircraft Recognition Society on January 10 were won by members of the Royal Netherlands Air Force team. These included two awards being presented for the first time, the Bristol Britannia Trophy for the highest individual scorer, and a model of the Fokker D.21 awarded by the Chief of Staff of the R.N.A.F. to the highest-scoring individual in the Service teams.

Apart from these two awards, which went to A. Van Niekerk, the R.N.A.F. team won the Silver Hurricane Trophy, awarded to the outright winners of the contest, with a total of 91 out of a possible 105 points, and the B.E.A. Viscount Trophy for the top Service team. The Aircraft Recognition Society team also scored 91 points, but as the R.N.A.F. team gave more ancillary information, they were made runners-up and awarded the "Air Pictorial" Silver Trophy.

The Silver Hercules Trophy for the best cadet team went to No. 276 (Chelmsford) A.T.C. Squadron, which consisted of Cdt. Sgt. J. R. Daniels, Cdt. Flt. Sgt. P. J. Combes and Cdt. Cpl. C. M. Howlett. Cdt. Cpl. Howlett also won the "Air Pictorial" award for the highest-scoring A.T.C. or C.C.F. cadet.

R.A.F. Aircraft Recognition

FIFTY TEAMS of three members each will represent the Commands at home, 2nd T.A.F. and the Royal Observer Corps in the 1958 R.A.F. Aircraft Recognition Competition to be held at the Science Museum, South Kensington, on March 15. As the sixth in the series staged by the R.A.F., the competition is for the Handley Page Trophy, which is a model of a Victor.

Fighter Command has won the competition for the past two years, with a team from R.A.F. Chivenor in 1956 and one from R.A.F. Church Fenton last year. The 1957 individual winner was Observer Officer J. T. Gill of No. 7 Group, Eastern Area, R.O.C., Bedford.

SCOTTISH GLIDING.— A.T.C. cadets inspecting a Slingsby Type 31 Tandem Tutor at R.A.F. Turnhouse after the official opening of a new A.T.C. gliding school on the station by Air Vice-Marshal P. D. Cracroft on January 18. The school will provide gliding facilities for cadets from Edinburgh, Glasgow and the south of Scotland.

The Disastrous Story of Singapore

by Air Marshal Sir Robert Saundby

IF our literature is a reliable guide to our national feelings, the British are at least as proud of their defeats as of their victories. They are particularly fond of those incidents which combine an element of folly with disaster, such as the charge of The Light Brigade or the oversetting of the "Royal George," or which add futility to failure such as the attempt to block Zeebrugge and Ostende in the First World War or the airborne operation at Arnhem in 1944. We seem to revel in such episodes as the retreat from Mons, the evacuation from Dunkirk, and our numerous disastrous expeditions among the hills of the North-West frontier of India.

But there was one grave military defeat in the last war about which we write little and say less. The fall of Singapore, our naval base and key strategic position in the Far East, after a short campaign lasting only seventy days, came as a great shock and surprise to the British Commonwealth. Many people felt that the loss of this vital fortress after so brief a campaign was inexplicable and shameful, and that those on the spot must have been guilty of a serious lapse from the high standards expected of our fighting forces. The magnitude of the disaster was apparent to all, but the sequence of events—the errors, the omissions, and the procrastinations that made the disaster inevitable—was understood by few.

Now it is all plainly set out in a recently published volume of the official "History of the Second World War."*

To find the causes for this terrible failure we have to go back as far as 1921, and trace the story of the origin, purpose, and defensive organization of the Singapore Naval Base. In 1921, it was decided to abrogate the Anglo-Japanese Alliance, which had been of great value during the First World War, in the hope of improving our relations with the United States. The Japanese deeply resented this action, and our worsening relations with them and the growing power of the Japanese Imperial Navy forced us to pay attention to the need for a naval base in the Far East. In 1922 the Admiralty decided that the best site for this base would be on the Johore Strait, on the northern shore of Singapore Island. In February, 1923, the Cabinet approved this proposal, and at the Imperial Conference later that year Australia, New Zealand, and India pressed for work to be put in hand at once.

Work, however, had hardly begun when the first Labour Government came into office in 1924, and decided that the Singapore project should be abandoned in the hope of improving the prospects for general disarmament. This Government was short-lived, and when it fell towards the end of the year the continuance of the work was authorized by its successor.

A sub-committee of the Committee of Imperial Defence was set up to examine the defence of Singapore Island against likely forms of attack. It was immediately apparent that the three Services were far from united in their views as to the best way of defending the new base. The War Office took the view that the nature of the country would make any attack by way of a landing in Malaya and an advance southwards through Johore exceptionally difficult. They insisted, and the sub-committee accepted, that any attack on Singapore Island must come from the sea.

The question of the best way of defending the island from a sea-borne assault caused a difference of opinion among the Chiefs of Staff, and started an inter-Service controversy that lasted for ten years. The Air Ministry claimed that reconnaissance aircraft, torpedo-bombers and fighters, supplemented by medium-range gun defences, could provide a cheaper and more effective defence against a sea-borne expedition escorted by naval forces than could long-range heavy guns. They pointed out that such an enemy force could be attacked far beyond the range of any heavy gun, and that since aircraft were mobile all the air forces required for the defence of Singapore need not be permanently stationed there in peace-time. Provided that the airfields and other facilities were in existence, a part at least of such air forces could be stationed elsewhere in peace, and moved to Singapore in time to meet a threat of war, with considerable economies in defence expenditure.

The Admiralty and the War Office, on the other hand, insisted that the heavy gun was the only reliable and proved deterrent against seaborne attack and that, with improved fire-control technique, including spotting by aircraft, it would continue to be so. They made much of the fact that the heavy gun batteries were fixed and permanent and therefore ready at all times to go into action, whereas the aircraft, being mobile, might not be available when required. In addition, the Admiralty at that time was particularly concerned not to admit that aircraft could sink or even seriously damage any kind of warship, and certainly not a convoy of military transports escorted by battleships with all the usual panoply of ancillary vessels.

After eighteen months of indecision the Committee of Imperial Defence recommended that the first stage of the Singapore defences should include, in addition to the medium gun defences, a battery of three 15-inch guns, and that the question of substituting aircraft for the remaining heavy guns should be re-examined later.

A Financial Wrangle

An argument then developed between the Service Ministries and the Government of Singapore as to apportionment of financial responsibility. The Colonial Government insisted that no part of the cost should fall on the civil community. This again delayed the work of selecting the sites and acquiring the land for airfields, batteries, cantonments and other military works.

In 1929 the second Labour Government came into office, and decided that further efforts should be made, in spite of the discouraging failure of the League of Nations to make any progress whatever in this field, to obtain international agreement to some form of general disarmament. A Naval Disarmament Conference was held in London in 1930 and the British Government, taking the extraordinary view that the signing of the Kellogg-Briand Pact outlawing war had made war improbable in the foreseeable future, offered not only to reduce our naval strength still further but to suspend work on the Singapore Base pending the result of the League of Nations Disarmament Conference. In April, 1930, the London Naval Treaty was signed and a "go-slow" policy for Singapore was reaffirmed by the Government and reluctantly accepted by an Imperial Conference later that year.

In 1931 the Japanese, taking advantage of a carefully contrived incident in Manchuria, began open hostilities against the Chinese. The situation in the Far East deteriorated rapidly, and in 1932 a Japanese expeditionary force landed a few miles from the International Settlement of Shanghai.

It was clear that our position in China and Malaya was threatened, and the Chiefs of Staff persuaded the Government to abandon the assumption—that there would be no major war for 10 years—which had done so much to hamper our defence policy.

In spite of this the strengthening of our defences in the Far East was still held up. There had been a serious financial crisis in 1931, and the Government was deeply concerned about our financial position. For several years the view of the Treasury—that the financial danger to the country was greater than the military one—prevailed. Indeed, it used to be commonly said in the Service Ministries in those days that the Government appeared to be more anxious to ensure that we had enough money to pay the reparations that would be the consequences of our defeat, than to avoid that defeat itself. In addition, the inter-Services controversy as to the best way of defending the Singapore base from seaborne attack had not been resolved. The Committee of Imperial Defence, in 1926, had merely postponed taking any decision. The improved performance of aircraft and the development of the airborne torpedo since 1926 made it difficult for the Admiralty

*The War Against Japan; Volume 1, The Loss of Singapore. H.M.S.O., 55s.

to claim that the heavy gun could provide the only reliable deterrent, and so the argument largely centred upon the question of the mobility of the air squadrons. The Admiralty and the War Office held that an overseas base must always be safe against surprise, and since Japan was unlikely to give any warning of an attack and might strike when we were preoccupied elsewhere, the defences of Singapore must be fixed and permanent.

A special Committee, presided over by Mr. Baldwin, at that time Prime Minister, was set up to make a decision. The Committee recommended in May, 1932, that the heavy gun should be regarded as the main deterrent against seaborne attack, and that air forces were to be considered a valuable and essential addition to the fixed defences, as well as a means of attack. These recommendations were accepted by the Government, which also decided to accelerate the first stage of the defence programme, which was far behind schedule, and to provide a second airfield and some additional squadrons.

Meanwhile the situation in Europe and the Far East continued to deteriorate. In 1935 the Government authorized work to begin on the second stage of the Singapore defence scheme, which included several more heavy guns in emplacements and two additional airfields. It was considered that on completion of the second stage Singapore should be able to hold out against the estimated scale of Japanese attack until the arrival of the British Fleet. This period of relief, as it was called, was estimated as 70 days.

Combined Exercises

We used to do a combined exercise in those days, in which all three Service Staff Colleges took part, on the defence of Singapore. This exercise was based on two assumptions; first, that any assault against the base must be seaborne, and secondly that the arrival of the British fleet would solve all problems and remove all dangers. At this time I was an instructor at the R.A.F. Staff College, and I remember some of us questioning both these assumptions and becoming unpopular in certain quarters for doing so. We were far from convinced—and we were supported by those with local knowledge—that an overland attack via Johore could be ruled out as impossible. With regard to the second assumption, we argued that the Japanese would probably not attack Singapore unless we were already engaged in a European war, and then it would be very doubtful if we could send a sizable fleet there at all. The arrival of the fleet, unless it were in overwhelming strength—which was hardly possible owing to limitations we had undertaken as a result of the Washington and London Naval Treaties—would, we thought, rather add to our difficulties than otherwise. It would require continuous protection from shore-based aircraft, which would leave fewer available for the active defence of the base. The official view, however, prevailed, and these two assumptions continued to provide the basis for the defence of Singapore.

After the outbreak of war in 1939 the Government decided to employ any forces that could be spared from the European theatre to defend Egypt and the Suez Canal against the Axis forces, mainly Italian, in North Africa. The rights and wrongs of this strategic concept are too involved to be sorted out in this article, but the fact remains that we decided to defend the Suez Canal, which was the by-pass road to the Far East, rather than defend the eastern part of the Commonwealth and the territories from which we drew vital supplies of tin, rubber, food and oil. And, moreover, it was a by-pass road which, owing to our inability to use the Eastern Mediterranean in the face of Axis sea and air power, we could not use anyway. Even the supplies and reinforcements for the defence of Egypt had to go via the Cape, a journey of some 10,000 miles, which made it as far away as Singapore itself.

Nevertheless, that was our policy, and so even the barest minimum of air and land forces considered necessary for the defence of Singapore could not be provided.

On October 16, 1940, the commanders of the three Services at Singapore submitted a joint appreciation of the situation to the Chiefs of Staff. As it was clear that no fleet of any size could be spared for the Far East, they agreed that air power would be the principal weapon for the defence of Malaya. They considered that the most probable form of attack would be from Japanese forces based on Siam, via the Malay peninsula. The air forces were to repulse an enemy invasion force while it was still at sea or, if they failed in this, to oppose his attempts at landing. The Army was to undertake the close defence of the naval base and the airfields, and destroy any Japanese forces which, in spite of air or naval action, had succeeded in getting ashore. They estimated that the R.A.F. would need a total of 566 first-line aircraft, a figure later increased to 582 by an additional squadron at Rangoon.

Though the three commanders were in broad agreement as to what was required for a successful defence of Singapore, they had divergent views as to the best way of employing the inadequate forces actually available. The Government therefore decided to appoint a Commander-in-Chief, Far East, to be responsible for the defence of Malaya, British Borneo, Burma and Hong Kong. Air Chief Marshal Sir Robert Brooke-Popham, who had retired from the R.A.F. in 1937 and returned to the active list on the outbreak of war, was appointed C.-in-C., Far East.

The Admiralty, however, would not agree to the control of naval operations being the responsibility of the new C.-in-C., and these remained in the hands of the Admiral Commanding-in-Chief, China. The new appointment, therefore, though designed to solve the problems of co-ordinating the defence of the area, "did little more," in the words of the official historian, "than add another cog to an already somewhat complex machine. Since control of naval forces was excluded, there were two Commanders-in-Chief in Singapore, each responsible to a different authority in London."

Although everything possible was done by those on the spot to improve the position, nothing could offset the fact that there were not enough air forces to carry out the tasks allotted to them, and not enough troops to defend the beaches, the airfields and the naval base. At the beginning of December, 1941, when the Japanese attack was imminent, the R.A.F. in Malaya had a first-line strength of 158 aircraft with 88 in reserve. Many of these were obsolescent types, and there was not one squadron of modern fighters available. The Army was almost as badly off, and the strength of the defence forces, as a whole, was far below the estimated minimum.

The arrival of one modern battleship, "Prince of Wales," and one 20-year-old battle-cruiser, "Repulse," was more of a political than a military move. The official historian comments: "It was hoped that the presence of the two ships would act as a deterrent to Japanese aggression. It was a bluff and the bluff was called."

Air Superiority Lost

The Japanese landed on the east coast of Malaya at dawn on December 8, 1941. Severe attacks on our airfields did fatal damage to our air forces, and from that moment we had no chance of achieving air superiority. Although warned that fighter cover could not be provided, Admiral Sir Tom Phillips took his ships into the South China Sea in the hope of finding and intercepting Japanese seaborne forces. Admiral Phillips was one of the staunchest of those naval officers who believed that aircraft were incapable of doing serious harm to capital ships. On the morning of December 10 his squadron was attacked by waves of torpedo aircraft and bombers, and the "Prince of Wales" and the "Repulse" were sunk after an action in which the Japanese lost three aircraft. This misfortune had no effect on the outcome of the campaign but—as the official historian relates—"the loss of the two great ships cast a gloom over the whole of the English-speaking World. In Malaya, where for years the people had been led to believe that once the fleet arrived all would be well, the shock was profound."

On December 23, Sir Robert Brooke-Popham was relieved as C.-in-C. by Lieut.-General Sir Henry Pownall. By this time the situation in Malaya was desperate. Reinforcements, including four Hurricane squadrons and an armoured brigade, were on their way from North Africa, but they arrived too late to be of any use. On January 20, the Army Commander, Lieut.-General Percival, warned the Chiefs of Staff that the situation might soon necessitate a withdrawal to Singapore Island, and that the defence of the island would depend on the number of men which could be successfully withdrawn. By the end of January the battle for Johore had been lost, and with it the Malay peninsula. The naval base was now useless, and it remained only to hang on to Singapore Island for as long as possible to deny it to the Japanese.

But the island was indefensible, now that the mainland had gone. The heavy guns, installed at so great a cost, had proved

useless, and all the airfields were under shell-fire. The air forces were almost annihilated and then, the final crushing blow, the water supplies were so damaged by enemy artillery-fire that by February 14 only about 24 hours' supply remained.

On February 15, 1942, the island fell, after a heroic resistance. The campaign, which lasted seventy days, never had a chance of succeeding, owing to shortages of everything that mattered. Over 130,000 men fell into the hands of the Japanese, who treated them so brutally that many thousands died of starvation and overwork.

In retrospect, what were the reasons for this appalling failure? Underlying everything was the fact that, owing to futile hopes of disarmament and appeasement, which still seem—in spite of all our experiences—to have a strong hold on the minds of our people, and a belief that financial stability was more important than military security, we entered the War in 1939 so short of everything we needed that it took more than three years to recover. Apart from that, it was due in the main to two causes. First, we failed as a nation to understand the meaning and importance of air power. Faced with Inter-Services controversy, the politicians inclined to temporize and compromise, with a bias towards the old-established views of the Admiralty and the War Office. The result was that we left it to Germany and Japan to exploit air power to our disadvantage. Secondly, it was due to our mistaken strategy, which rated the Middle East and the Suez Canal as vastly more important than our Far Eastern commitments.

As we move away from a major war we tend to forget that, in this world in which we live, good intentions, moral ideas, and our passionate desire for peace are no substitutes for adequate and up-to-date armed forces. Few people, I suppose, will read this volume of the official war history, but if it does anything to make us realize the inexorable facts of life, its publication will help towards our survival as a free nation.

The R.A.F.—The Next Generation

THE Korean War is invariably cited as an example of a limited war, when the subject of air power in such wars is spoken of or written about. Air Marshal Sir Robert Saundby wrote an excellent article in THE AEROPLANE of December 27, entitled "Equipment Requirements of the R.A.F.," and from it one can infer that these requirements are, in the main, for limited wars. His article was necessarily controversial and contained a number of statements which I think should be challenged.

Sir Robert has previously expressed his general approval of the 1957 White Paper on Defence and, it appears to me, his latest article has been written with his previous expositions in the forefront of his mind. To strengthen his case Sir Robert underrates the air opposition which could be encountered in a limited war and consequently underestimates the performance necessary for aircraft which would be used in such a war.

Undoubtedly, as Sir Robert asserts, small wars will be fought against the Communists or their stooges. It follows, therefore, that if these stooges provoke a war they will be well equipped by their masters to fight one. The quality of the Soviet fighter and bomber arm suggests that the opposition they could provide would be very formidable indeed. A fair indication of the regard for the potential power of Soviet-designed aircraft may be seen in the thoroughness with which the British and French High Commands destroyed the Egyptian Air Force in the Suez operations. Had these aircraft been manned by Soviet "volunteers" I believe they would have been more than a match for our Wyverns, Venoms, Sea Hawks and Canberras. The jet bombers would also have constituted a serious threat to our warships and transports at sea.

Sir Robert says that it is necessary to have a reasonable degree of air superiority, and the enemy air forces, if they exist, must be destroyed or effectively subdued. This is, of course, true, but I disagree with Sir Robert's contention that this can be achieved by a fighter/ground-attack aircraft, with a speed of 1,100 m.p.h. The next generation of fighters, whether or not the R.A.F. will have them, will have speeds considerably in excess of this figure. The American Voodoo and F-104, the English Electric P.1 and the new Russian fighters are very much faster than Sir Robert's suggested fighter/ground-attack aircraft. Two British projects recently postponed or abandoned, the Hawker fighter and the Saunders-Roe interceptor, appeared to be the ultimate in fighter design and technique. To achieve this performance, a fighter design cannot be compromised by considerations for ground attack, although it may well be that, having achieved air superiority, such a fighter could be used for ground-support duties.

We must not forget that the standard British day fighter, the Gloster Meteor, was outclassed in combat by Chinese-flown MiG-15s over North Korea. Hard-pressed, too, was the F-86, but the technical excellence of its equipment enabled it to meet the MiG on something like equal terms.

So to achieve air superiority our fighter must, at least, be on equal terms of performance.

For ground attack we have at present several squadrons of Hunters, and anyone who has seen their performances at Farnborough displays will be convinced of their deadly potential. The Hunter airframe is, however, dated, and it is only a near-sonic machine. A project for a thin-wing Hunter with a more powerful engine was abandoned some time ago. Such an aircraft would now be contemporary with the F-100 and could, when it became obsolescent, have continued giving excellent service with ground-attack squadrons.

The rate of attrition in the ground-attack rôle is high, and a relatively cheap, lightweight aeroplane is necessary. The Gnat Mk. 2 project, with its 1,000-m.p.h. speed, may fill this rôle, although its progenitor, the Mk. 1 Gnat, was ruled out of the NATO lightweight competition by design aspects stemming from its primary rôle as an interceptor.

Again, to assess the future interdictor light bomber, we must consider the opposition it is likely to encounter. It must be able to live with enemy fighters and it seems that a supersonic performance is essential at low and medium altitudes, say up to 35,000 ft. The interdictor outlined by Sir Robert would appear to be very similar to the Canberra Mk. 8 and, notwithstanding the Canberra's attributes, I do not think it could operate against tactical targets, especially in daylight, without suffering prohibitive losses.

The American B-66 is the present aircraft which exhibits design trends and tactical applications conforming to my suggestion for a future light bomber although, of course, it is not supersonic. It has a considerable advantage in performance over the Canberra at medium altitudes. Tail armament provided on the B-66 will, I believe, continue to be effective on supersonic bombers. For some years the Canberra PR.9 will be outstanding as a high-altitude reconnaissance aircraft, especially useful for operations in parts of the World where visibility from extreme altitude is usually to be had, such as in the Middle East.

Ideally the light bomber of the R.A.F. should also be in service, carrier-borne, with the Navy. I do not doubt that supersonic bombers capable of STOL or VTOL will eventually be developed. For some considerable time the Navy must use the new Blackburn attack-bomber, provided with long-range (Scimitar) fighter escort.

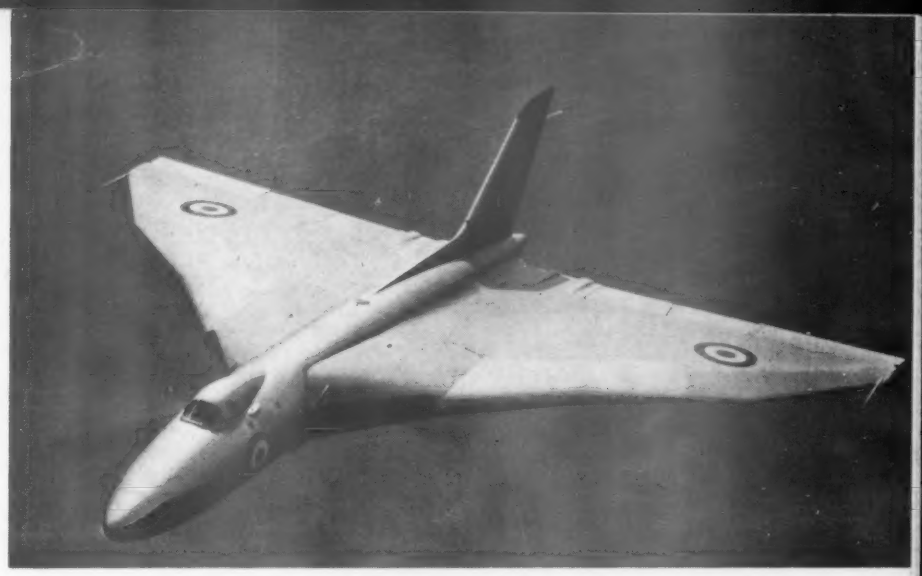
I agree with Si. Robert's appraisal of helicopter supply generally, but besides his option for a large number of a small type I think a few squadrons should be equipped with a larger type, such as the new Bristol 192.

A convincing case is hardly made out by Sir Robert for production of a new type for operations in such cases as occurred recently in Oman and on the frontier of the Aden Protectorate and the Yemen. In the large helicopter carrying conventional bombs and rocket missiles, and other aircraft now in service, we have enough different types efficiently to make the necessary air operations.

For maritime operations, undoubtedly the Canadair CL-44 is the most advanced aircraft but such a costly type would deter any plans, at least for the present, of producing it for Coastal Command. In these circumstances it does indeed seem to have been false economy to have abandoned the project for a Shackleton powered by four Napier Nomads.

To my mind there is no doubt whatsoever that the industry is capable of designing and producing the next generation of aircraft for the Services. The fundamental trouble is that the British people do not really want an air force. If they did, I am equally sure the Treasury would find the money more readily than they do now.—S. WALFORD NICHOLAS.

More about the Vulcan



A FEW weeks ago, as a result of an official Press visit to Avro's Chadderton and Woodford factories to see something of the production of the Vulcan, we were able to give a preliminary survey of the problems and processes involved. (THE AEROPLANE for December 6 and 13, 1957). Of necessity, the space, and time, then at our disposal restricted our survey to a very brief discussion. We are now, however, able to give the subject the fuller treatment it deserves and in the following pages we deal at much greater length with the structural features of the World's largest operational four-jet delta-wing aeroplane and with some of the interesting methods that have been adopted in order to build it.

As we said in our preliminary report, by most standards the Vulcan is an impressive aeroplane and represents a remarkable aeronautical engineering achievement. Despite its radical layout and its size, development from the initial work on the prototype to the acceptance of the aircraft in squadron service last September has been notably trouble-free and commendably swift. Indeed an elapsed time of no more that 8½ years—from the receipt of the official Instruction To Proceed with the prototype to the delivery of the first production-type aircraft to the R.A.F.—has been recorded.

However, the development history of the Vulcan and the part played by the Avro 707 series of small delta research aircraft, has already been given in our pages (THE AEROPLANE for September 27, 1957) and does not need to be repeated here. Suffice to say that the first prototype Vulcan, powered by four Rolls-Royce Avons, flew for the first time in August, 1952, and made its public debut at the S.B.A.C. Display of that year—only two days after its initial flight. Later, that prototype was re-engined with Armstrong Siddeley Sapphires.

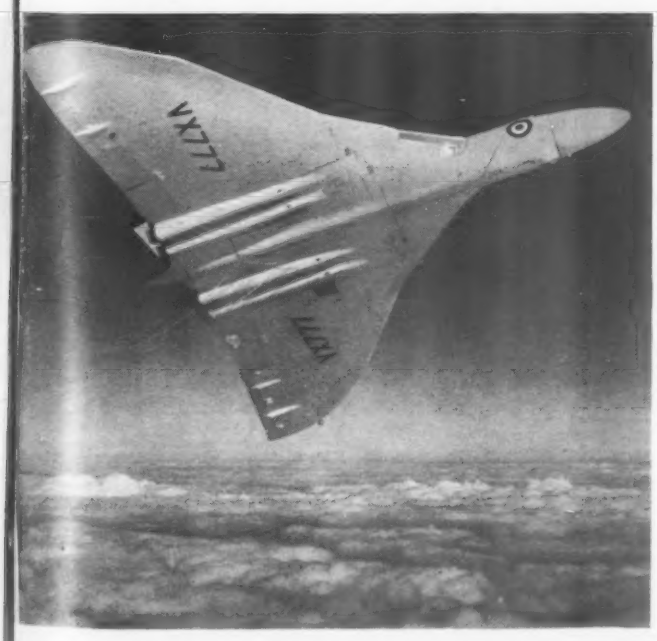
Production Vulcans were, however, scheduled to have the Bristol Olympus two-spool turbojet and the second prototype made its initial flight with powerplants of that type in September, 1953. This aircraft was, in effect, up to production standard as it incorporated all the changes that had been made in the first. But the production flow really started in February, 1955, with the maiden flight of the first Service aircraft. This was delivered to the R.A.F. for trials in March, 1956 and C.A. Release was obtained two months later.

Aerodynamically, the Vulcan has claimed a good deal of attention by reason of its delta planform and when it first appeared there was much discussion anent the advantages and disadvantages of such a layout. Initially the wing of the aircraft was very nearly a true delta with a straight leading edge swept back at 50° and only a small tip chord. In 1955, however, a modified planform was introduced having a compound sweepback obtained by increasing the chord at a point about three-quarters of the span out from the centre-line. Inboard, this was faired by a straight line to about the semi-span point and outboard to an increased tip chord. These " breaks " in the straight leading edge were located at points that would reduce the structural alterations to the portion forward of the front spar to a minimum. In this form, the wing has an aspect ratio of 2.78 compared with 2.84 in the original version.

At the time this change was made, it was said that it permitted the fullest operational use to be made of the more powerful engines then about to come into service. The extra thrust available gave increased operating altitude and an inevitable increase in compressibility effects—so that a local reduction in thickness/chord ratio would clearly pay a useful dividend. Furthermore, the corresponding reduction of loading over the outer part of the wing, due to the increase in chord, also proved beneficial in improving the high Mach number characteristic.

For the Mk. 2 Vulcan—which will have the more powerful Olympus 6 with a static thrust of 16,000 lb., and is presumably the aircraft intended as the carrier for the Avro stand-off bomb—a modified wing has been produced. In addition to having an increased span (by 12 ft.) this wing also has a more pronounced compound sweep on the leading edge. This has locally been brought even farther forward and the resulting aerofoil section has a markedly drooped nose.

These changes, and a general thinning of the outer portion of the wing, give a greater area to counteract increases in the operational weight and height of the aircraft, and provide a planform and aerofoil section that would again reduce the compressibility effects which are generally aggravated by the increase in height available with the more powerful engines. This modified wing was seen at the S.B.A.C. Display last year, on the second prototype of the Vulcan B Mk. 1 which was referred to as an aerodynamic prototype of the Mk. 2 aircraft.



Photograph copyright " The Aeroplane "

As described above, the wing of the Avro Vulcan B. Mk. 2 has been given an increased span and more pronounced compound sweepback on the leading edge. This photograph is of the aerodynamic prototype.

As a result of the changes its aspect ratio has become 3.1 instead of the 2.78 of the original production type.

For an aircraft intended for operation at high-subsonic speeds the overall thickness/chord ratio at the root of the wing appears at first sight to be rather higher than one might have expected. At the transport joint between the centre-section and outer wings it is, in fact, 10% and is progressively increased inboard. One has to remember, however, that thickness ratio as such over an area which contains the turbojet powerplants and, therefore, a good deal of intake ducting is not really a true indication of the aerodynamic thickness of the wing in that region. In fact, the effective t/c of the Vulcan wing root is much less than the overall 12% given by outside dimensions.

With a chord of some 46 ft. at the wing transport joint, the depth over the root portion is more than enough to accommodate the two Olympus turbojets each side in buried powerplant bays. Each engine is, in fact, contained in a separate compartment divided into a number of fire zones by spanwise diaphragms and surrounded by firewalls. On each side there is a common near-rectangular air intake for each engine pair and this divides into individual branches before the front wing spar is reached. Installation of the engines is a comparatively simple matter and generous access doors are provided in the underside of the wing over the engine bays for this purpose.

So far as crew accommodation is concerned, the Vulcan conforms to the standard pattern laid down for the V-bombers which all carry a crew of five. Entrance to the flight deck is by means of a hatch under the fuselage nose and located just forward of the nose-wheel leg. This gives access to an intermediate "landing" from which one can proceed forward via another short ladder to the pilot's flat or back to the line-abreast stations which are on a raised deck to the rear of the pressure cabin.

These three seats are of the normal parachute-pack type and face permanently aft. The air electronics officer is stationed in the right-hand seat (facing aft) with the navigator in the central position and the radar operator on the left.

As we said in our previous article, the flight deck proper is surprisingly compact, with the two pilots' ejector-type seats fairly close together, and all the controls and switches neatly to hand. The view forward and downward over the nose, despite the comparatively small size of the individual panels making up the windscreen, is remarkably good. Sideways view is afforded by a circular porthole, conveniently placed just about level with the pilot's head. And because of the need to have a "solid" canopy in a high-speed fully pressurized aircraft, side periscopes have been provided at each pilot's position to give a view over the outer wings and tail.

A fully powered control system is, of course, a prerequisite for a high-performance aeroplane the size of the Vulcan and for this Boulton Paul electro-hydraulic power-packs have been chosen. The systems for the elevators and ailerons are fully duplicated with these surfaces divided into two separate portions on each wing—each powered by its own unit. There is no cross-linking from port to starboard—so that if, say, an elevator power-pack system fails the remaining three elevator surfaces will continue to be operational.

The control runs themselves are of the normal push/pull rod type with appropriate bell cranks and levers. There is no manual reversion but aerodynamically balanced surfaces are used to reduce the load on the power units. A q-feel system is, however, incorporated in the elevator circuit which loads the pilot's controls in accordance with the airspeed. The feel units also provide a means of preventing the pilot from applying too great a control surface deflection under conditions when this might prove dangerous.

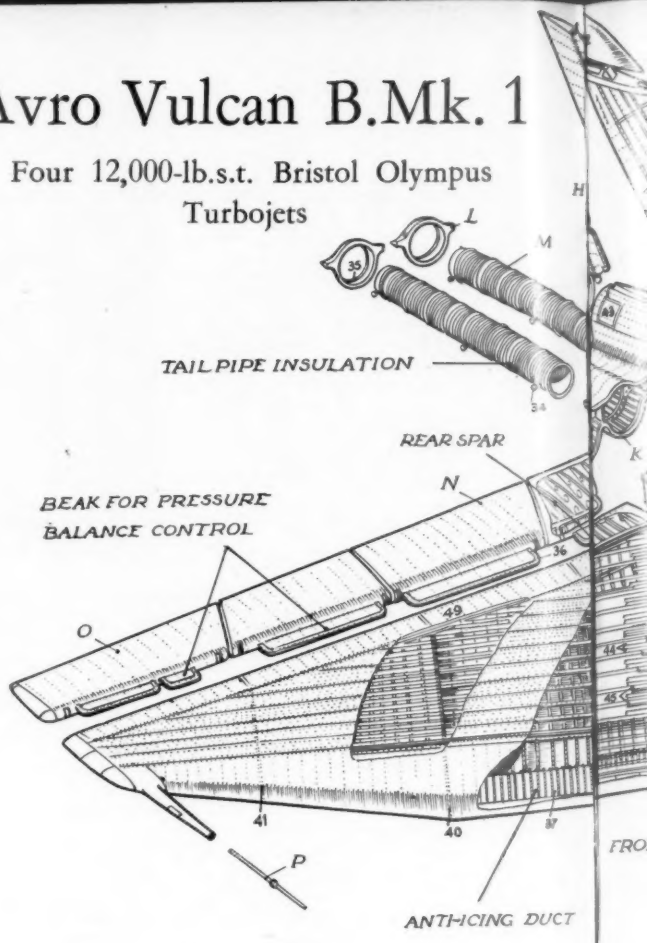
Basically each feel unit comprises an input rod compressing a spring through the medium of a slotted lever pivoting about a variable fulcrum point. The effort needed by the pilot's lever to compress the spring depends on the position of the fulcrum point and for the elevator this is controlled, through an actuator, by airspeed—i.e., by a function of $\frac{1}{2}\rho V^2$ (which is usually symbolized as "q," and hence q-feel).

Thus at low airspeed the pivot point is high up in the slot giving a large mechanical advantage to the pilot's lever and in consequence a "soft" feel. Conversely, at high airspeeds the pivot is moved towards the lower end of the slot, decreasing the mechanical advantage and progressively hardening up the control.

Basic information for this feel system comes from an air-

Avro Vulcan B.Mk. 1

Four 12,000-lb.s.t. Bristol Olympus Turbojets



KEY

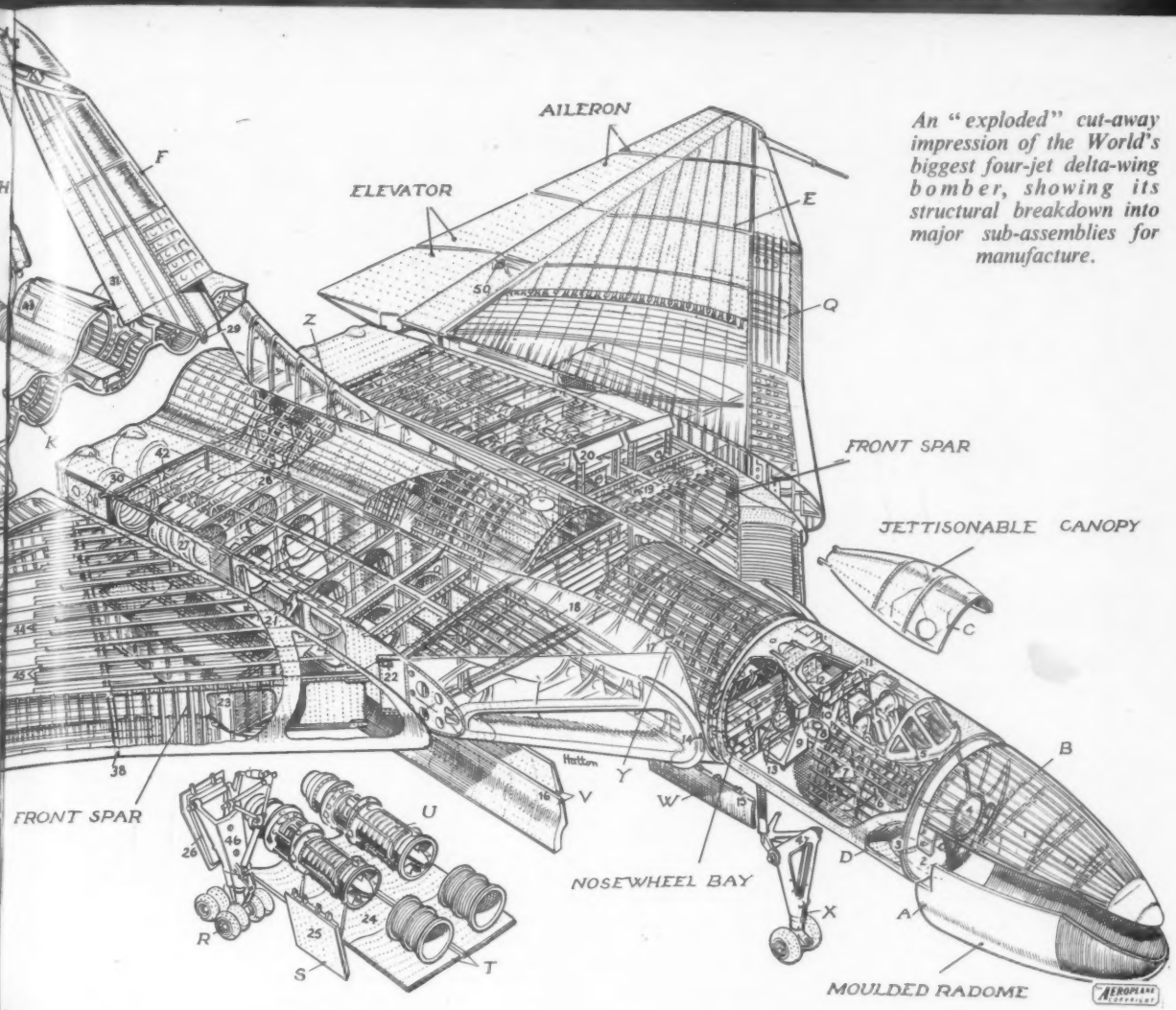
1. Cantilevered nose structure.
2. Front pressure bulkhead.
3. Bomb aimer's window.
4. Access door.
5. "Sandwich"-type windscreen.
6. Entrance door.
7. Flight deck.
8. Periscope.
9, 10, 11. Radar operator, navigator, electronics officer.
12. Dinghy stowage.
13. Rear pressure bulkhead.
14. Cabin air intake.
15. Nose-wheel door.
16. Bomb-bay door.
17. Fuel-tank space.
18. Centre-section rib st
19. Air-brake guide stru
20. Air-brake (honeycom
21. Main-wheel pivot po
22. Front-spar upper jo
23. Main wheel-bay stru
24. Engine-access doors.
25. Main-wheel door—fr
26. Main-wheel door—re
27. Engine tail-pipe fair
28. Rear spar passing th
29. Fin main-spar fusela
30. Rear-spar upper join
31. Rudder shroud.
32. Fin moulded tip.
33. Moulded rear fairing
34. Jet-pipe insulation a

speed transmitter which unbalances a Wheatstone bridge circuit and operates the actuator. When, for example, there is an increase in airspeed, the transmitter unbalances the Wheatstone bridge one way and causes a micro-relay to make "high" contacts. This energizes another relay feeding current into the actuator in such a way that it moves the pivot towards the input rod and stiffens the feel. On the fulcrum lever is a cam which moves with the pivots and operates a follow-up ratiometer. This balances the Wheatstone bridge and stops the actuator when the fulcrum point appropriate to the airspeed has been reached. The same sort of sequence is followed when there is a decrease in airspeed.

A similar feel system is incorporated in the rudder circuit but in this case the force rate is proportional to V^3. The aileron has a simple spring feel with stops "monitored" by "q," thus reducing the available aileron angle at high airspeeds.

Structural Details

For the wing of the Vulcan, a straight-forward two-spar structure has been chosen. Over the centre portion—which has cut-outs in its under-surface for the bomb bay, engine bays, and wheel wells—the skin and stringers of the top surfaces are made to do a relatively larger proportion of the work than those of the bottom surface. In point of fact, at the transport joint between the centre section and outer wings, all the bending loads are taken by the bottom spar joints; whereas on the top



An "exploded" cut-away impression of the World's biggest four-jet delta-wing bomber, showing its structural breakdown into major sub-assemblies for manufacture.

35. Jet-pipe end caps.
36. Pressure-balance attachment "beak."
37. Anti-icing ducting.
38, 39, 40, 41. Main ribs.
42. Warren girder structure of engine-bay rib.
43. Tail parachute stowage.
44. Top-hat section stringer.
45. T-section stringer for skin panel joint.
46. Main-wheel casting.
47. Nose-wheel casting.
48. One-piece rudder and torsion box.
49. Wing control-surface shroud.
50. Elevator-hinge point.

Sub-assemblies

A. Nose radome.
B. Nose top decking.
C. Canopy.
D. Front fuselage.
E. Outer wing.
F. Fin.
G. Fin cap.
H. Rudder.
J. Rear fairing.
K. Rear fuselage.
L. Jet-pipe end cap.
M. Jet-pipe insulation.
N. Elevator.
O. Aileron.
P. Pitot head.
Q. Wing leading edge.
R. Main-wheel unit.
S. Main-wheel doors.
T. Engine-bay doors.
U. Powerplants.
V. Bomb-bay doors.
W. Nose-wheel doors.
X. Nose-wheel unit.
Y. Nose-wheel bay, intake assembly.
Z. Main wing centre-section.

surface these loads are taken in part by the skin and stringer combination.

For the spars themselves it was decided to use the well-tried orthodox boom and web construction rather than attempt to break new ground with such things as plank spars. In the main, the booms are extruded sections in D.T.D. 363.

In the case of the front centre-section spar—which has a lozenge-shaped contour—the top and bottom booms are formed to follow the appropriate curves. This is done after they have been milled to the correct basic T-section. After this bending operation, the booms are subjected to another milling operation which produces the necessary angle on the outer (skin) surface of the T-section. This angle varies along the boom from the aircraft centre-line to the wing transport joint. These booms do not actually follow the fuselage contour—only the increase in wing depth as a result of crossing geometric generating lines.

At the rear centre-section spar position, the wing depth is constant from one side to the other. For this reason the booms are made to run straight across while the top and bottom boundaries of the spar web are stiffened by a lighter angle-section secondary capping members, to fair into the fuselage lines.

As the rear spar is, of necessity, comparatively shallow, the distance between the main booms is less than the overall required depth for the engine bay cut-outs. This meant, of course, that one or other, or both, of the spar booms had to be cut in four places and means found to carry the boom loads round the apertures. In point of fact, it is the bottom boom only that has been "interrupted" in this way and the strength replaced by four sturdy high-tensile steel rings. This material was selected so as to get the required strength and stiffness with a minimum bulk and weight.

This expedient is not necessary in the case of the front spar which is deep enough to accommodate the engine-bay apertures without cutting the booms. In this case, then, the four holes in the webs are stiffened in the usual way with extruded angle-section rings.

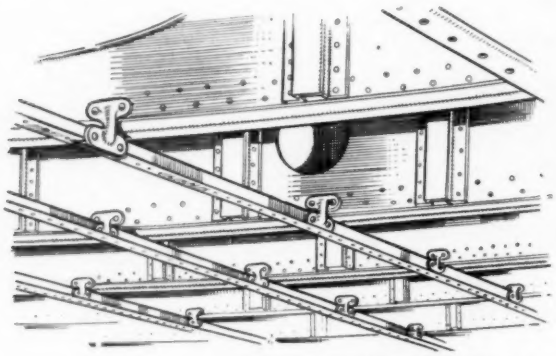
The front and rear centre-section spars form the fore-and-aft boundaries of the bomb bay and most of the loads across the underside of the fuselage have to be carried by the lower spar booms. Over the top portion of this bay the loads are transferred by a series of relatively closely spaced arch beams—these are built-up units, the construction of which varies according to their position; in the main they have T-section top and bottom booms with plate webs having flanged lightening holes. At each side of the bomb bay thus formed there are two parallel bomb-bay ribs which take the actual bomb load into the main spars.

These side boundaries of the bomb bay are sturdy bulkhead ribs with single webs. Their top booms are angle sections and the bottom ones inverted T-sections. Over the centre section the top fuselage skin is in panels with longitudinal inverted

top-hat section stringers which lie on top of the arch frames. At each skin joint the butt is made on a T-section stringer.

Between the two engine bays on each side of the bomb bay there is a sturdy webbed girder-type rib with built-up square-section booms and members in the girder portion at the rear. Plate webs cover both sides of these ribs over about the front three-quarters of their length. The transport joint ribs which form the outboard wall of the outermost engine bays are also boxed-up ribs with double webs but these have extruded channel-section, rather than box, booms and members.

There is comparatively little "fixed" skin under these engine bays in the centre section as most of the area is taken up



Drawing copyright "The Aeroplane."

A detail drawing showing the "butterfly" links used for the attachment of stringers to ribs in the outer wing structure.

by access doors. Where this occurs, the top skin is supported by fairly deep intercostal beams made up of angle-section booms and plate webs.

For the inter-spar portion of the outer wings a system of closely-spaced ribs with angle booms and pressed plate webs stiffened by lipped-channel vertical members, is used. These units are set at approximately right-angles to the rear spar which sweeps backward at about 15°. The innermost rib forms the outer boundary of the main undercarriage wheel-well and for that reason is a specially sturdy structure to take the undercarriage loads into the wing box. Three other specially stiffened ribs are located at the hinge points for the control surfaces.

In the inboard portion of this part of the wing there is an inner skin to house the flexible bag tanks. This tank skin is located by, and attached to, the large flanged cut-outs in the appropriate ribs. The rib at the outer end of the tank bay is the bulkhead type.

Skinning of the outer wings between the front and rear spars comprises a series of spanwise panels stiffened by Z-section stringers. On each panel, however, one of the spanwise edges is stiffened by a T-section member which also forms a butt-strap for the panel joints. Generally speaking the stringers are extruded sections in DTD 683 for the top surface skin and rolled sections in DTD 687 for the bottom skin. The skin itself is DTD 687 material and is in 16 and 14 s.w.g. panels, according to their position.

Although Avros have done much pioneering work in sandwich construction, there is little of it to be found in the Vulcan. Indeed, except for such obvious applications as the airbrakes and access panels, the only sandwich panels used are on the underside of the wing between the transport joint rib and the outer undercarriage rib. The trailing edge under-skin in this region is light-alloy honeycomb while immediately aft of the wheel-well on the starboard side the skin is in metal honeycomb panels and on the port side glass fibre honeycomb dielectric windows.

The ribs are not notched to take the stringers which pass unbroken over the rib flanges. Stringer/rib connections are made by means of small forged "butterfly" links which are attached to each unit by rivets.

So far as the spars themselves are concerned, these are straightforward units, similar to those in the centre-section, with T-section booms and plate webs. The leading edge contains a spanwise duct for the thermal anti-icing system and a double skin in the nose, the inner unit of which is formed with shallow rectangular chordwise corrugations to transfer the heat flow from the duct. Where necessary, part-depth pressed nose ribs and some similar full-depth ribs complete the basic structure and the skin is supported by spanwise Z-section stringers.

Aft of the rear spar in the outer wing there is a trailing-edge portion which extends back to the control surface shroud. The whole underside of this portion is, incidentally, arranged to hinge down for access to the control rods and control surface hinges.

Matching this, over the centre section behind the rear spar, there is a comparatively light trailing edge and rear fuselage structure. In this there is a light spar, corresponding to the control surface shroud which is, in fact, a transport joint between the two rear portions. It is built up with angle booms and a plate web stiffened with top-hat verticals.

At this point the wing depth is, of course, quite shallow and a large part of the engine tailpipe fairing is below the lower surface of the wing. For this transport joint member, then, a considerable portion of the lower boom is interrupted by the aperture stiffening rings and the whole unit looks rather like a very large spectacle frame with four "eyes."

For the joints between the spars of the outer centre-section wings, the Avro design team have chosen, as in other parts of the structure, to use an extension of their previous well-proven techniques. Thus, one finds that a simple shackle-type spar boom connection—as used on the Lancaster, the Lincoln and the Shackleton—has been adopted for the Vulcan.

Here, the main problem has been to produce joint fittings that would deal with the sweepback of the outer wing spars. For example, in the case of the front spar these joint fittings are very large H.D.A. forgings in the form of a distorted Y with tongues set to correspond to the lines of the centre-section spar, the outer wing spar, and the transport joint rib. The two spar tongues are connected to their respective booms by means of sturdy shackles and steel bolts.

The leading edge of the main wing centre section comprises a portion of the front fuselage flanked by the two engine air intakes. Of this the central, fuselage, section is basically of circular cross-section and is composed of a straightforward structure with channel-section frames and skin panels supported on fore-and-aft top-hat stringers which pass unbroken outside the frames. In that part of the fuselage immediately forward of the front spar there is a nosewheel bay section which also houses fuel tanks, in its upper portion.

There are shelf members running along each side of the actual wheel-well below the tanks. On the

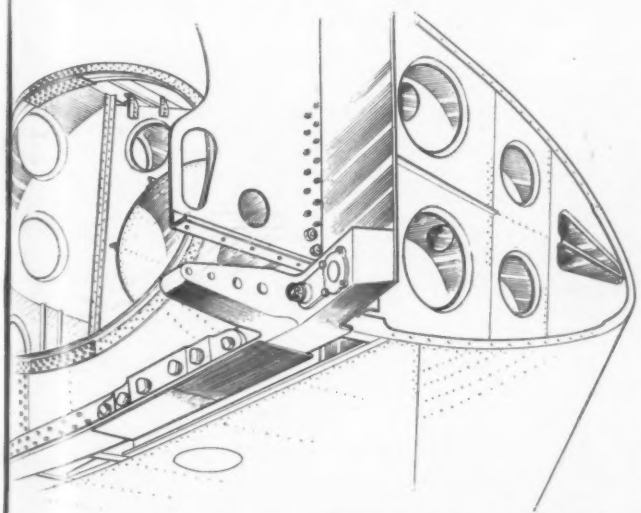
Outer-wing assemblies for the Vulcan are produced at Woodford. Here, a unit nears completion, while others in earlier stages of assembly can be seen in the background.

The fuselage nose-wheel bay, two side air intakes and the centre-section front spar are built as a complete sub-assembly at Chadderton.

shelves thus provided are located certain items of equipment and systems. For example, the air-conditioning unit and some electrical gear is carried on the port shelf while radio equipment is on the starboard shelf. In the underside of this nose-wheel bay the cut-out for the wheel is stiffened by two longerons which are tapered off towards the front spar. Further stiffness is provided by extensions of the bottom booms of the bomb bay ribs which are taken forward from the front spar to pick up the loads from the cut-out longerons. These loads are transferred across from the rib booms to the longerons by means of fairly heavy gauge skin panels and additional fore-and-aft stringers.

For the pressure cabin, much the same sort of structure as that for the nosewheel bay has been adopted, although there are some detail differences. Channel frames are used, outside which run continuous lipped-top-hat section stringers supporting the skin. As is the case of the wing, these skin panels are butt-jointed on T-section edge members. In order to take the pressure loads into the webs of the frames rather than into the flanges, the skin-stringer/frame joints are made through the medium of channel-section cleats which fit inside the top-hat stringers to be riveted to their side walls and riveted also to the back of the main-frame webs.

The front pressure bulkhead is a simple shallow dish unit made up of eight segment plates butt-jointed by radial straps.



Drawing copyright "The Aeroplane"

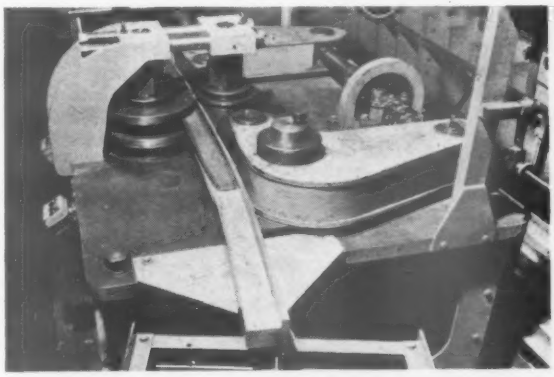
Sturdy forged joint fittings are used to connect the top and bottom spar booms of the centre-section and the outer wings. Shackles are used to link the matching units.

In the centre of this bulkhead is a circular access door to the radar equipment bay. As the bomb aimer's window is almost directly under the pressure bulkhead the lower portion of the dish has had to be cut off flat to accommodate it. Strength across this flat has been restored by a built-up beam-cum-torsion-box member.

At the rear of the pressure cabin is a flat bulkhead so chosen in order to conserve fore-and-aft space and also to provide a comparatively simple means of dispersing the nose-wheel loads into the structure. On the rear face of the bulkhead are two sturdy extruded channel-section vertical members which carry the main loads and form an anchorage for the leg hinge fittings. There are other vertical stiffening members on the rear face of the bulkhead, while on the front face there are horizontally placed ones. Most of these stiffeners are of top-hat section.

In the top decking, the canopy cut-out is bounded by built-up box-section edge members which serve the double purpose of stiffening the necessarily large aperture in the pressure shell and of housing the canopy retention catches. There are, in fact, two of these catches each side which engage with pins on the canopy itself and are freed mechanically for emergency release. An explosive charge operates the release mechanism when either of the seat blinds is pulled—but manual operation is also available. At the rear end of the canopy there are two open-hook type hinges which free the canopy entirely once it has hinged back to a predetermined angle.

The windscreen panels are carried in forged light-alloy frames made as separate units and bolted up to form a complete



Bending the spar booms for the front centre-section spar. After bending, the top surface of the T is contour-milled to the appropriate skin angle.

assembly. Five panels—a central rectangular one flanked by two near-rectangular panels and two triangular side windows comprise the main windscreen unit. These are of the dry-air sandwich type, de-misted by hot air and de-iced by fluid.

Another large cut-out in the pressure shell is the underside entrance door. This, too, has large edge members both for strength and to provide a seating for the door locks and pressure seals. This door, incidentally, hinges downward, and incorporates the entrance steps. It is located towards the rear of the pressure cabin and in front of the nosewheel undercarriage, and is opened pneumatically to serve as an airstream deflector for emergency escape.

The extreme nose of the fuselage is made up of an upper top "decking" built as a cantilever portion forward of the pressure bulkhead. This decking is a normal light-alloy structure and contains a certain amount of systems equipment together with the fuel supply lines from the Flight Refuelling nose probe.

Below this top decking is the large radome which contains the complex and extensive apparatus appropriate to a modern V-bomber. This radome is a double, Fibreglass-Hycar sandwich moulding and is reckoned to be the biggest one-piece unit of its kind made in this country—if not anywhere in the World.

Construction of the large swept fin of the Vulcan is similar to that of the outer wings and so also is its attachment to the

centre section. The fin has two built-up spars and closely spaced interspar ribs. At the centre of the main rear spar of the centre-section wing there are two fairly closely spaced full-depth vertical members. These accommodate at their upper end a forged joint fitting with two tongues on which are picked up the front fin spar and the bottom fin rib. The attachment is made by means of shackles similar to those used in the main wing joints. The rear fin spar is similarly attached to corresponding vertical members on the rear transport-joint spar.

Magnesium alloy is used to a large degree in the structure of the movable control surfaces—largely with a view to keeping their weight to a minimum and reducing the mass-balancing problem. All these surfaces—rudder, ailerons and elevators—have a single spar carrying the necessary hinge fittings, and light channel-section pressed ribs.

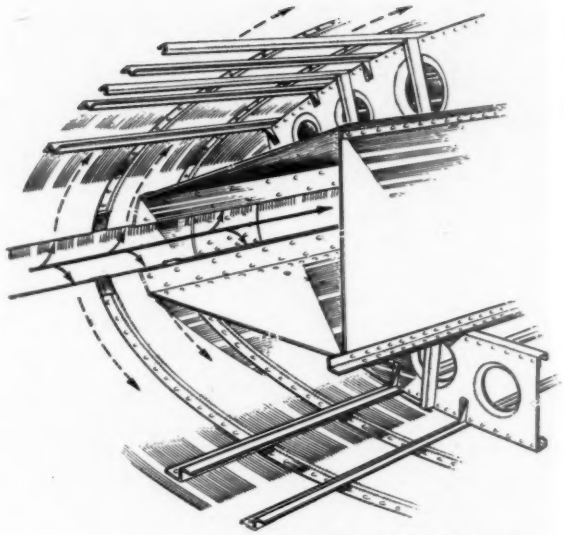
Production Techniques

Although, as we have said, the general techniques employed in building the Vulcan are straightforward enough, a great deal of ingenuity has gone into the production planning and into some of the detail processes adopted. Primarily, of course, those problems that have arisen have largely been associated with size, for the sheer bulk and unusual shape of some of the components has in many cases made them a little difficult to produce.

For this reason, a great deal of attention has been paid to striking the right sort of compromise between production and design requirements and it is noteworthy that the team responsible for building the Vulcan is very complimentary about the way their design-office colleagues have been prepared to co-operate. Similarly, much careful thought has had to go into the problem of breaking down the airframe into sub-assemblies of reasonable size for production and transport without too great a sacrifice in weight and complication of extra structural joints.

Throughout the production lines a "kit marshalling" system has been adopted as the most suitable means of ensuring a steady procession of sets of components into the major and minor assembly jigs. Another noteworthy system used at Avro's Chadderton factory is that whereby all the rolled sections used in the Vulcan airframe—and these have been reduced by careful detail design to a minimum number of different sections—are made on the premises and put into the material stores rather than rolling them in smaller pieces on a component basis. This is found to save basic manufacturing time and to minimize delays on the sub-assembly lines.

So far as jig and tool design is concerned, there is only a small tool design office at Chadderton as most of the jigs and manufacturing processes are developed on the factory floor by adapting standard and well-tried practices. In point of fact only about 20% of the tools used in the Vulcan production lines have had to be designed in the tool design office. Most of the tools used are made by the company, but during peak demands in this direction about 50% of the tool manufacture is sub-contracted to other companies.



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A detail of the leading-edge duct system for the thermal anti-icing system in the outer wing.

Broadly speaking, the major sub-assemblies comprise the pressure cabin complete; the centre-section leading edge which includes part of the front fuselage and the two air-intakes; the main wing centre-section interspar portion which includes the bomb bay and the engine bays; the centre section trailing edge and rear fuselage; the outer-wing leading edge; the outer-wing interspar structure; and the outer-wing trailing edge. To complete the airframe there is the extreme nose top decking, the radome, the fin, the movable control surfaces, and the bomb doors.

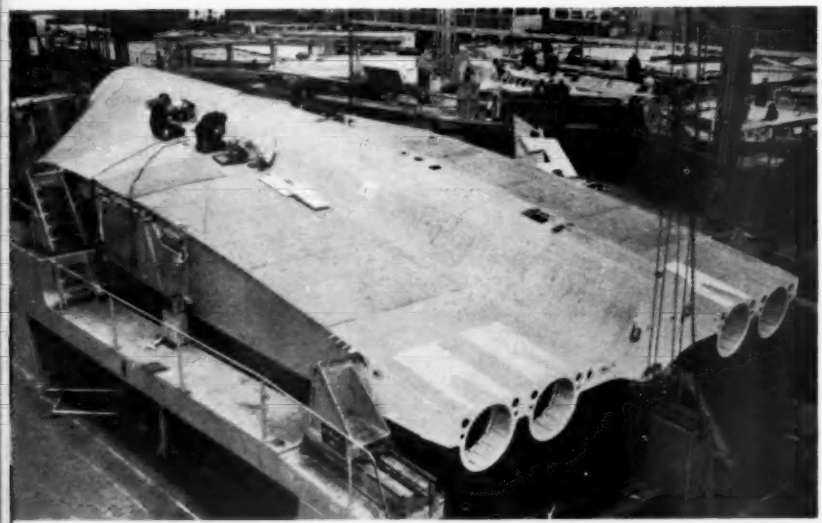
For the manufacture of the Vulcan's huge radome, a normal vacuum-type moulding process is used—the whole unit being produced as a one-piece moulding in three stages. In the first, the outer Fibreglass sheet and Hycar phenolic sponge layer are built up and cooked at 75° C. for three hours in an autoclave at 26 in. Hg. Next, the second Fibreglass/Hycar layers are added and another three-hour cooking at 75° C. takes place. Finally, the innermost Fibreglass sheet is added to complete the double sandwich. These three oven stages are made necessary because various inserts between the layers have to be added and it is not practicable to do the whole operation in one "cooking."

Control of the final thickness and thickness distribution of the radome is most important and on a unit of such size it is difficult to establish these factors within the accuracy required. Avro's research department have, however, devised a special electrical comparator for checking the thickness.

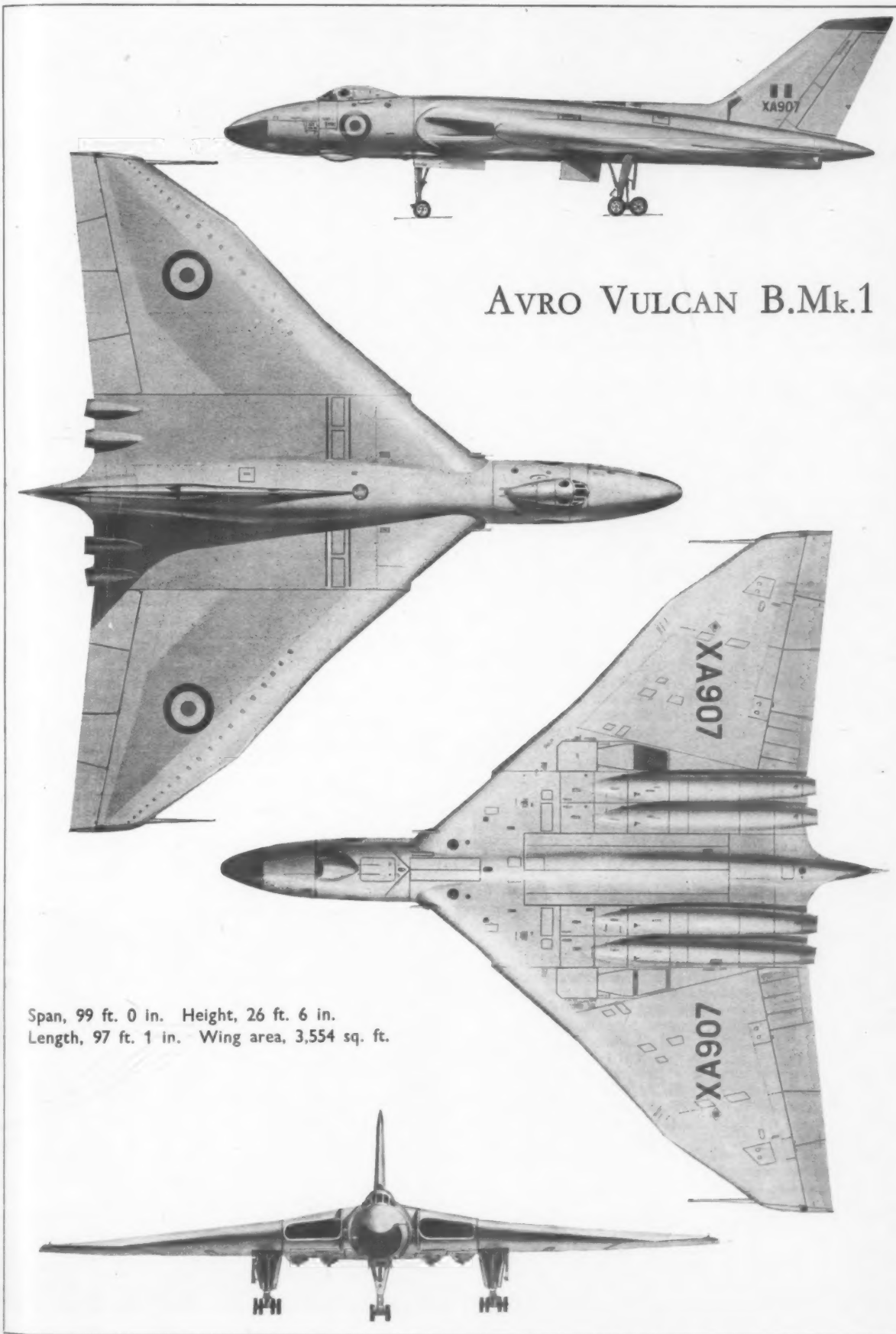
For most of the larger sub-assemblies—which are built at Chadderton—extremely sturdy jigs have had to be provided. Indeed, they are rather more massive than one usually finds because the subsoil under the Chadderton factory is of a soft nature and, therefore, not particularly stable as a working surface. For this reason all the larger jigs have had to be built on very substantial steel rafts to give them a solid base. However, despite the problems added by this need, there is a counteracting advantage in that as a result all the main jigs are, in effect, transportable and any necessary rearrangement to suit production needs of the moment is thereby considerably simplified. It should be added that these large jigs incorporate aluminium-alloy members for temperature compensation.

As is only to be expected great care has been taken with regard to the all-important requirements

(*Continued on page* 150)



The complete centre-section of the Vulcan in course of final assembly at Woodford; this has the intake and nose-wheel bay portion, and the trailing-edge portion aft of the rear spar, in place.



AVRO VULCAN B.Mk.1

Span, 99 ft. 0 in. Height, 26 ft. 6 in.
Length, 97 ft. 1 in. Wing area, 3,554 sq. ft.

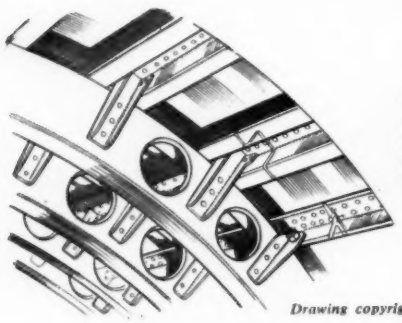
"The Aeroplane" copyright drawing by Roy Cross

(*Continued from page* 148)

of component interchangeability. In this respect, we were told during our visit that the heavy jigs employed have ensured 100% interchangeability of major components and 98% in the case of semi-major components—which is good by any standards. All the jigs are optically checked every month.

By far the biggest and most complex of the major sub-assemblies is the centre section which as a complete unit, without its leading and trailing-edge portions, measures about 30 ft. long by 26 ft. wide. For convenience this is built in sections before it is put together in the main sub-assembly jig. For example, the bomb-bay is built as a separate unit comprising the side ribs and arch frames. The bomb-bay arches are themselves built up in multiple jigs having movable fixture heads that can be located in a series of marked positions to make a number of different arches at a time.

In the case of the initial batch of airframes this massive centre section was transported as a single piece to the final assembly line at Woodford some 16 miles away. However, because of the transport difficulties arising from its size the interspar assembly has now been modified and the structure



Channel cleats are used to attach the fuselage-skin stringers to the webs of the channel frames.

Drawing copyright "The Aeroplane."

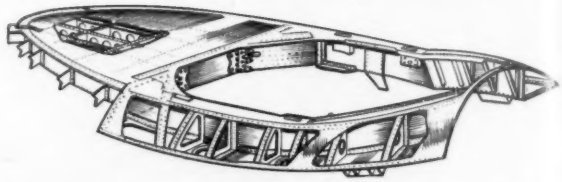
arranged so that after assembly at Chadderton it can be split on the centre line into two more easily handled portions for transport to Woodford with the front and rear structural assemblies, which are not split, as separate units.

The centre-section leading-edge sub-assembly is first made as three individual smaller assemblies—the most complicated of which are the air intake portions. For these the building sequence is to make the top and bottom half-lips, after which they are assembled into full-lip units which can then be jig-assembled with a front false-spar (that is swept back to lie approximately parallel with the leading edge proper) and some rib structure. This intake nose unit is then put into a vertical jig in which further ribs and skin are added to complete the structure back to the main centre-section front spar line which lies normal to the aircraft's centre-line.

This completes the leading-edge intake assemblies and the port and starboard units are then transferred from the vertical jigs into a normal horizontal jig where they are assembled on to the fuselage nose-wheel and tank-bay section.

Built in Fairey envelope jigs to ensure accuracy of aerofoil profile, the leading-edge units for the outer wings are assembled at Chadderton. They form a complete sub-assembly which includes the front spar of the wing. As the envelope jig system necessitates building inward from the skin the last components to be assembled in the leading-edge jigs are the main spar webs. In point of fact, the T-section booms are first assembled with part-depth sub-webs which leave the interior of the leading-edge in the jig accessible—while at the same time they provide the requisite stiffness during assembly and form a simple and straightforward means of attaching the main web to the spar.

Bases for the envelope jigs are made of light-alloy box-section members forming a very firm structure upon which the jigs proper can be built. Originally the bases were carried on eight steel legs mounted on flat plates, but with this arrangement temperature changes caused considerable distortion—by as much as a ¾-in. "wind" over the 60-ft. length of the



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The cockpit cut-out is bounded by this sturdy edge member which takes the pressure loads and forms an attachment for the jettisonable canopy.

jig. To cater for differential expansion and avoid this sort of distortion, the feet were removed and the light-alloy structure was placed on roller boxes attached to a steel raft. At one end of this basic jig structure is an optical telescope and at the other a collimator so that check measurement of any movement can be made.

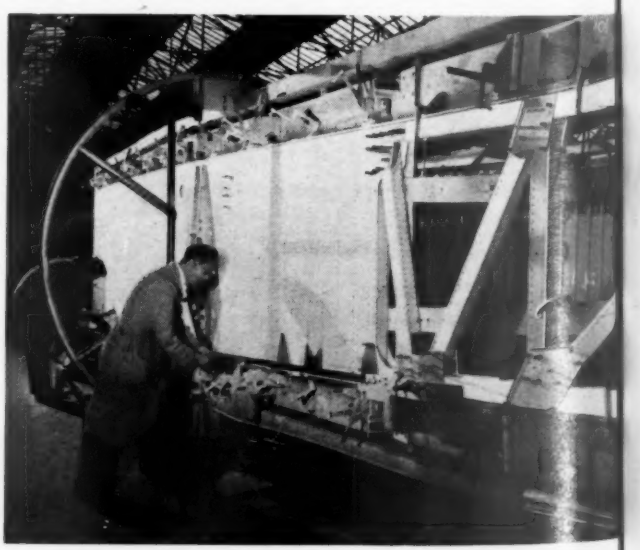
The method that was adopted for setting up the jigs is interesting. The nose-contour boards which support the jig skin had ½-in.-diameter holes jig-bored in them to represent horizontal and vertical datums. Steel bars with similar holes to coincide with those on the vertical datum were also bored so that an optical graticule could be mounted on the intersection of the two datums. These bars were used with the telescope and colimator, mentioned earlier, to position each skin contour board accurately in the light-alloy jig structure. Once this was done the contour cut-outs in the boards were angled off.

To ensure perfectly matching surfaces between skin and jig envelope, the jig skins were stretch-formed over the same blocks that are used to produce the actual aircraft leading-edge skins. For this purpose, of course, a slave skin of the correct thickness had to be inserted between the block surface and the jig skin.

In production, the first operation of the leading-edge assembly sequence is to locate and clamp the nose skins in position while location holes are drilled, through which the skins are bolted. The skin joints are then marked out, the skins cut to size, placed in the jig and bolted up. Skin butt-straps are next fitted and riveted to turn the leading-edge skin itself into a single unit. The de-icing corrugations are then located, drilled and riveted to the skin, after which internal ducting angles and stringers are inserted and pop-riveted to the corrugations.

The half ribs and full-depth ribs can then be attached to the stringers and skin and all internal riveting is completed. All that remains is for the spar booms to be fitted and finally, as already mentioned, the closing webs riveted into place. When this is done the leading edge is virtually complete as a major sub-assembly.

Once the leading-edge is out of the jig the countersunk rivet



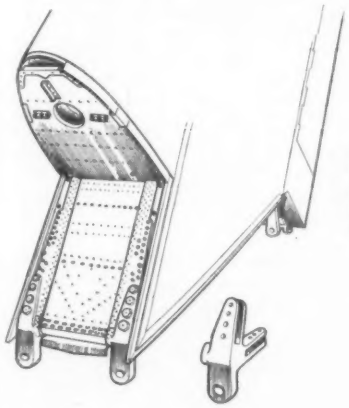
The massive engine-bay rib with its double-webbed forward portion and Warren-girder rear.

This underside view of an early Vulcan, having the original straight leading edge, shows the disposition of the air-brakes and the various cut-outs below the centre section.

Photograph copyright "The Aeroplane"

heads are milled absolutely flush with the skin surface. Here, perhaps, it might be mentioned that because of the sharpish nose radius in the leading-edge, rivets with small 60° heads are used. These are made on die extrusion machines specially for this purpose.

In the leading-edge, too, as already explained, there is an inner skin with shallow chordwise ducts for the thermal de-icing system. These inner skins are in comparatively small panels, spanwise, and are first folded to form the duct "corrugations"; They are then rolled in Farnham rolls to the correct leading-edge contour.



Attachment of the fin front spar to the centre-section rear spar is similar to that used for the main wing joint.

Drawing copyright "The Aeroplane"

Despite the length and cross-sectional area of the spar booms, the milling of these units is a straightforward operation and has not called for any out-of-the-ordinary machinery or processes. An interesting technique that has, however, been adopted for quenching the booms after their solution heat treatment is to do this operation vertically in deep baths. It was found that immersing them in horizontal baths resulted in sundry twists and winds in the booms that were difficult to avoid.

As in the case of the leading-edge, the main outer-wing rear spar forms part of the trailing-edge sub-assembly which includes the control surface shroud.

This, then, leaves the interspar structure to be built; and to save time spent in the main wing assembly jigs, this is, in fact, put together as a separate sub-assembly. For this, an intermediate jig is used in which all the interspar ribs over the fuel-carrying portion of the wing are assembled and temporarily attached to jury stringers.

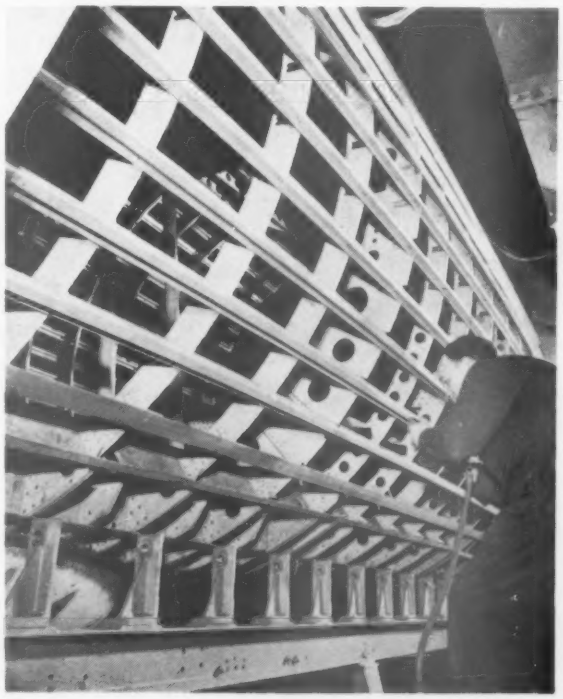
In this jig all the wing skin panels are pre-drilled *in situ* and then taken off for de-burring prior to final assembly. The tank-bay inner skins are also fitted in this intermediate wing jig, but they, too, are removed for later assembly.

When these preliminaries are completed, the entire interspar rib structure, with its jury stringers, is transferred to the main outer-wing assembly jigs and dropped between the leading- and trailing-edge sub-assemblies. In this jig the outermost interspar ribs are added and the tank skins and outer skins finally riveted into place to complete the structure.

After this the wing unit is then removed from its build jig and put on to a mobile trolley-type stand where it is equipped with its various fuel tanks and piping, control runs, hydraulic-system equipment and so on. On these trolleys the wings are mounted on screw jacks so that their height and "angle of attack" can be adjusted for precise offering-up to the centre section.

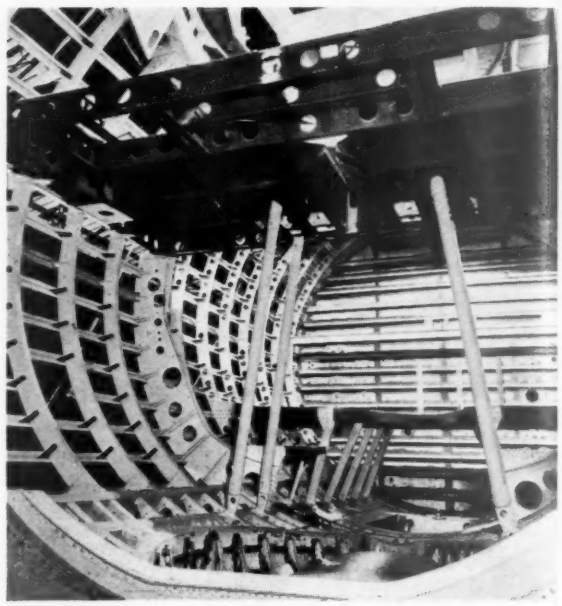
These wing-assembly jigs are arranged alongside the main assembly line at Woodford, which starts with the receipt of the centre-section halves. These are first joined up to make a complete unit, which is then put into a large assembly jig, where the centre-section leading- and trailing-edge portions are added.

When this has been done the entire centre-section unit is lifted out of the jig by overhead crane and placed on a mobile wheeled trolley. This can then be moved into position farther



This close-up of the Vulcan's fuselage structure gives a very good idea of the stringer-and-frame layout adopted. Except in special cases the fore-and-aft stringers all pass outside the frames.

Right, an interior view of the front-fuselage structure showing the flight-deck and crew-station floor members. Below, a general view of the Vulcan final assembly line at Woodford.



down the line, ready for the centre-section to receive the pressure cabin—which by this time has had the top nose decking added—the outer wings and the fin. At a somewhat later stage, when the airframe, as such, is virtually complete and much of its equipment in place, the undercarriage units are installed so that the now-recognizable Vulcan can move forward out of the trolley jigs on its own wheels. All that remains is the installation of the powerplants and the final processes of equipment and systems installation followed by checks in the pre-flight hangar.

From this pre-flight hangar, production Vulcans come at short intervals. But how short, is one of the things Security will not permit us to reveal.

As we have already said, for such a radical design of aircraft, its structure and manufacture are surprisingly orthodox. That this as a policy has paid off is, perhaps, indicated by the fact that recently, out of five Vulcans off the production line at Woodford, two were actually cleared for Service acceptance on their initial flights. And this would also seem to indicate the excellent standard of serviceability that is obtained with these latest units in Bomber Command's deterrent armoury.—F.T.M.

Vulcan Suppliers

Among the principal suppliers of materials and equipment for the production of Avro Vulcans are the following companies:—

T. I. Aluminium, Ltd.; Automotive Products Co., Ltd.; Avica Equipment, Ltd.; Bell's Asbestos and Engineering, Ltd.; Belling and Lee, Ltd.; Birmetals, Ltd.; Birmingham Aluminium Castings Co., Ltd.; Thomas Bolton and Sons, Ltd.; Thomas Boorn and Co. Ltd.; James Booth and Co. Ltd.; Boulton Paul Aircraft, Ltd.; British Aluminium Co., Ltd.; British Electric Resistance Co., Ltd.; British Insulated Callender's Cables, Ltd.; British Thomson-Houston Co., Ltd.; Brown Bayley Steels, Ltd.; Cellon, Ltd.; Deritend Drop Forgings Ltd.; Diamond "H" Switches, Ltd.; Dowty Equipment, Ltd.; Dunlop Rubber Co. Ltd.; Dzus Fasteners (Europe), Ltd.; English Steel Rolling Mills Corp. Ltd.

Ferranti, Ltd.; Flight Refuelling, Ltd.; Fireproof Tanks, Ltd.; Firth-Vickers Stainless Steels, Ltd.; Thos. Firth and John Brown, Ltd.; S. Fox and Co. Ltd.; Hellerman, Ltd.; High Duty Alloys, Ltd.; Hymatic Engineering Co. Ltd.; General Electric Co. Ltd.; Sir George Godfrey and Partners, Ltd.; Graviner Mfg. Co., Ltd.; Marconi's Wireless Telegraph Co. Ltd.; Marston Excelsior, Ltd.; Martin Baker Aircraft, Co. Ltd.; Miller Aviation, Ltd.; Normalair, Ltd.; Northern Aluminium Co. Ltd.

Palmer Aero Products, Ltd.; Plessey Co. Ltd.; Pulsometer Engineering Co. Ltd.; Rotax, Ltd.; Rubery Owen and Co. Ltd.; Sangamo Weston, Ltd.; Self Priming Pumps and Engineering Co. Ltd.; Smiths Aircraft Instruments, Ltd.; Simmonds Aerocessories, Ltd.; Standard Telephones and Cables, Ltd.; J. Stone and Co. Ltd.; Teddington Aircraft Controls, Ltd.; Teleflex Products, Ltd.; Herbert Terry and Sons, Ltd.; Triplex Safety Glass Co. Ltd.; Tungum and Co. Ltd.; and Vickers-Armstrongs, Ltd.

From the Lecture Room

The Scope of Area-rule

ONE of the most useful aerodynamic design techniques of recent years was the development of the Area-rule method of relating the drag at transonic and supersonic speeds to the geometry of the aircraft. Mr. R. T. Whitcomb of the NACA Langley Aeronautical Laboratory, who received the 1955 Collier Trophy "for the discovery of Area-rule," gave two lectures on the subject at the Training Center for Experimental Aerodynamics at Rhode Saint-Genèse, Brussels, on January 21 and 22.

He began by stating the basic tenets of flight at transonic and supersonic speeds when the formation of shock waves results in energy losses or increased drag of an aircraft, drastically increasing the power requirements at these speeds. The drag-rise is related to the cross-sectional area of the aircraft and it is necessary to redesign a basic project to reduce the supersonic wave-drag. The best example of this is the Convair B-58 Hustler, the total supersonic drag of which was reduced by one third after re-shaping the fuselage, engine nacelles and pod.

Area-rule may be applied up to a Mach number of 2.0; above this the basic concept and the linear theory used both break down. At higher speeds, said the lecturer, Area-rule "is not an important design tool." On the other hand, there is promise of considerable benefits to be attained at high subsonic speeds.

First applications of Area-rule were for sonic-speed flight, but it was soon found to apply both above and below M = 1.0. An 8-ft. section transonic wind-tunnel was used to evaluate the effects of such variables as wing planform, body shape, wing/body combinations and the flow-fields produced. By this means the principles of Area-rule were arrived at and it was established that wave-drag is a function of the axial distribution of cross-sectional area.

Reduction of Drag

If drag is a function of cross-sectional area along the length of an aircraft, then the lowest drag will be attained by the use of a slender body with low wave-drag. Such shapes have been suggested by the slender-body theoretical work of Sears and Hack. For the purposes of Area-rule an indentation is made in the body to remove cross-sectional area equivalent to that of the wing, the wave-drag then being the same as that of a comparable body of revolution with the same cross-sectional area at transonic speeds.

In comparing the results for swept and delta wings it was found that the delta-wing layout produced larger secondary effects because of the very rapid change of area with length, the corrected body shape changing abruptly at the wing trailing-edge.

From the practical viewpoint, it is usually the case that volume cannot simply be taken away from the fuselage because the stowage requirements for crew, engines, undercarriage, fuel and payload have to be met. In this case, the drag may be reduced by the judicious addition of volume. [A prime example of this is the Convair F-102 Delta Dagger, which became supersonic only after bulges were added to the tail end of the fuselage which increased the cross-sectional area and the length—Ed.] When starting a new design with the method of Area-rule in mind, it is possible to locate the basic components of the airframe to suit the required area-distribution.

Since the original method of sonic-speed Area-rule was devised, the technique has become considerably more sophisticated and no design work is now done by the "simple" method as first propounded. The first aeroplane to be designed by this method—the Grumman F11F-1 Tiger—has since been "re-ruled" in the light of extensions to the method made for supersonic flight. The changes in shape include a forward extension to the wing root and a slimmer fuselage.

In supersonic flight the general nature of the flow is different from that in the transonic region. The disturbances produced by the passage of the aircraft are conical in form and not planar because the aircraft is, by definition, always moving faster than its disturbances (which travel at sonic speed) and they are swept back behind it at the appropriate Mach cone-angle.

Whereas cross-sections in planes normal to the longitudinal axis are considered for subsonic and transonic speeds, for supersonic speeds the cross-sections taken are at planes tangential to the Mach cone surface. It is necessary to take an average of several such sections; three sets are sufficient. The drag is a function of these area developments. The theory of supersonic Area-rule is based upon a consideration of area development and has been extended for more complex arrangements of flow potentials.

The most important theoretical application is that, by use of Area-rule, equivalent axially-symmetrical bodies can be found, amenable to theoretical calculations for drag (i.e., slender-body theory). If a fuselage were non-circular in cross-section, there would be more chance of getting least-drag by applying supersonic Area-rule. This would involve the use of quadripoles rather than simple sources. Good agreement of theory with experiment has been obtained with "hourglass" fuselage cross-sections used in conjunction with unswept wings of elliptical planform, the normal Area-rule method giving little improvement in this case.

The moment-of-area method has produced the idea of indented secondary bodies mounted in the wings, the fuselage being indented for the area of the secondary bodies and the wing. In this way the indented bodies provide for disturbances in the outer part of the wing while the fuselage indentation covers disturbances in the root regions.

Practical Problems of Application

One problem is that of pressure waves reflected by the wing when it is set off-centre in either the low or high position. Separate investigation is made of upper and lower indentations, the aircraft shape being divided in the plane of the wing. The wing is not, of course, a perfect "mirror" and in the case of a swept wing the disturbances may creep around it. However, in the region of the wing itself, the reflection can be assumed to be complete. Fore and aft of the wing, the areas considered are not divided.

Changes in area in the region of the wing produce twice the effect of the normal case because of the reflection. The area-distribution is not continuous when plotted lengthwise because of the discontinuities at leading and trailing edges. Drag is a function of these changes of area, not of the absolute areas as in the original "simple" Area-rule concept. Therefore, the slopes of the area-distribution curve are of the most importance. For full effectiveness of the fuselage it must be indented both above and below the wing. In the case of a high-wing design such as the Chance Vought F8U-1 Crusader, where it was difficult to have an indentation above the wing, a shoulder was added near the leading edge.

Cross-sectional areas at certain longitudinal locations of an aircraft are determined largely by the size and shape of cockpit, wing and tail. Thus, the beginning, middle and end of the area-distribution curve are more or less fixed. Ideally, the remainder of the curve would be filled in by computation of the required shape in order to attain a minimum drag envelope. However, at supersonic speeds, slender-body theory for fuselage fineness ratio is not applicable, as ratios well above the usual 8 : 1 or so are required. Hence non-slender-body theory would have to be used as a basis for calculation and this would complicate matters considerably. For this reason an empirical method has been devised, based on initial theoretical considerations by Parker.

The results obtained by using the Parker theory show a steep peak in the

PERSONALITIES AT BRUSSELS.—Top left, Mr. R. T. Whitcomb and Dr. R. P. Harrington (technical director, T.C.E.A.); top right, Mr. J. B. Edwards and Mr. P. C. H. White (Handley Page, Ltd.); bottom left, Dr. Ing. G. V. Lachmann (Handley Page, Ltd.) and Dr. F. Keune (Technische Hochschule Aachen); bottom right, Mr. Whitcomb in discussion.

Photographs copyright "The Aeroplane"

centre of the area curve and this shape can be closely approximated by drawing straight-line tangents between the cockpit, wing and tail requirements in the curve. Use of this technique gives a nearly ideal shape and approaches the ideal minimum drag attainable in theory. The Crusader was designed by this method, with excellent results.

Wing planform affects Area-rule and a swept wing is an advantage because of the smaller discontinuities at leading and trailing edges. The delta wing is good to above M = 2.0 and low aspect ratio helps at high Mach numbers. The full effects of planform are determined by analysis of area curves produced by taking the Mach cone tangential sections referred to earlier.

As stated above, it is generally necessary to take three sets of these. In the case of a highly swept wing of low aspect ratio the average taken is nearer to either end of the range, as is desirable.

Use of a 60° sweepback is a great help, but there is a great deal to be gained by tapering the wing in both planform and thickness more than is usual. By this means, the volume of the wing is moved closer in to the fuselage and gives the desired effect.

The design Mach number of a new design is the best compromise for all operating conditions, but the prospect is formidable and it is best to make a reasonable analysis of the requirements. Certainly, the maximum speed is by no means the prime consideration because most of the flight is at lower speeds, and it is very important that rapid acceleration is possible up to the maximum speed when this is needed. An average speed is designed for, about half-way between M=1.0 and the maximum speed. Thus, a fighter to have a maximum speed of M=1.4 would be Area-ruled for M=1.2.

The penalty of designing for maximum speed only is that the drag performance is good only at, and above, this speed. The critical condition is where the Mach cone-angle crosses the leading-edge angle of the wing and there is little to be gained when this speed is approached. Indeed, there are tremendous penalties at the lower end of the speed range for relatively minor improvements of the design case. The Mach cone-angle must always be less than the wing leading-edge angle and for this reason speed is the principal limitation of Area-rule.

Turning to considerations of flight at high subsonic speed, the aircraft configurations met are considerably different from those of the supersonic régime. Less sweepback is used in conjunction with higher thickness/chord ratio, aspect ratio, lift/drag ratio and lift coefficient. Lifting conditions, rather than the case of zero lift, are now the criterion.

The original work of Kuchemann related to indenting the fuselage sides to streamline them in accord with inswinging flow over swept wings at subsonic speeds. By this means the drag rise was delayed around M=0.9. This work has since been greatly extended to have an indentation right round the fuselage as in Area-rule shaping.

The snag of applying these very worthwhile techniques is that no manufacturer of large transport aeroplanes would wish to have an indentation in the region of the cargo compartment. This leads to the conclusion that additions to the basic cylindrical shape must be made which are both simple in form and light in weight. The best way of achieving this is to concentrate the addition in one place, the rest of the airframe being conventional.

Subsonic drag-rise is due to flow separations emanating from weak shock waves. If these can be reduced in strength, then the drag will also be reduced. Flow separation on a moderately swept wing occurs in the trailing-edge region at mid semi-span. It can be reduced either by twisting the wing locally or by cambering the fuselage to give positive lift. A bulge under the fuselage does not affect the wing in this way and so a humped forward fuselage is sufficient and delays the drag-rise by this primary addition to the basic cylindrical shape.

From the manufacturer's viewpoint, it is doubtful that such a major change of shape would be worthwhile in terms of overall benefit. So an attack was made on the seat of the trouble in the wing location itself. This takes the form of small streamlined bodies extending fore and aft of the wing trailing-edge. These bodies, about four on each side, slow down the airflow ahead of the shock waves and weaken them so that the basic separation is reduced.

In analysing the effect of these bodies, attention is localized by studying segments of them on local area curves. By using such a two-dimensional approach, the "vast store" of knowledge of two-dimensional aerodynamics can be used to obtain the best shapes and aerofoils. It has been found that the NACA 16 Series aerofoils are most suitable because of their characteristically flat pressure-distribution curves.

A vast number of arrangements have been investigated and some interesting results obtained, although the final results have not yet been published. In general, the fuselage addition alone is better at Mach numbers below about M=0.86 and with both fuselage hump and wing bodies there is an improvement at higher subsonic speeds.

This work has given a key to the general delaying of drag-rise. Sweepback is helpful but, if angles of more than 35° are used, the pitch-up problem becomes unacceptable for civil aircraft. At M=0.9 with both additions, high-speed pitch-up is "essentially eliminated." A further dividend is that there is no pitch-up at all if the sweepback is increased to 40° when these modifications are made, thus allowing a higher operating speed. It seems, therefore, that great improvements can be made at high subsonic speeds with high lift/drag ratios and the necessary aerodynamic knowledge "appears to be in hand."

The Lectures Discussed

SPEAKERS of several NATO countries contributed to the discussion and it was of particular interest to hear how two of the NATO light strike aircraft, designed before Area-rule results were available, had been modified.

ING. CZINCZENHEIM referred to the Breguet 1001 Taon which at first had been designed to the early Kuchemann theory. When Area-rule was applied by smoothing-out the area-distribution curve and reducing wing/fuselage interference by adding a planform radius at the leading-edge root, improvements were obtained in drag reduction and take-off performance. However, the wind-tunnel indication of a 40% reduction in drag coefficient proved to be 25% in full-scale.

DOTT. ING. UGO SACERDOTE of the Fiat Divisione Aviazione described the steps taken to modify the Fiat G.91 to Area-rule principles. In this case a complete redesign of the fuselage was not feasible and the only possibilities were the cockpit and external stores. Since the location of the stores was already fixed structurally in the wings, the only variable remaining was the fore-and-aft location, and a layout was eventually found in which stores on swept-forward pylons gave the desired effect, attaining a 6% reduction in drag.

From Sud-Aviation, M. ETIENNE FAGE described the problem of adding auxiliary fuel tanks to a swept-wing aeroplane which at first had reduced the high subsonic speed performance at high lift coefficients. An Area-rule investigation resulted in abandoning under-wing tanks in favour of small tip tanks and fuselage-side bulges just behind the nose. With this arrangement, the drag at M = 0.9 was better than without the tanks at lift coefficients up to 0.6.

M. Fage agreed with the lecturer on the high-speed limitations to Area-rule and quoted M = 1.4 as the best design speed for generally good results. Straight wings had been tried, but the severe discontinuities of the area curve resulted in a sharp fuselage indentation and associated local flow separation.

DR. F. KEUNE of the Technische Hoschschule, Aachen, felt that supersonic Area-rule theories were generally so complex that it was difficult for every worker to understand all the approaches. He referred to early work by Betz which had led to the moment-of-area method.

From the National Physical Laboratory, DR. R. C. LOCK referred to the extension of Kuchemann's idea to cover low supersonic speeds where, because of sweepback, the local airflow over the wing was still subsonic. It was important to obtain a pressure distribution at the wing/fuselage junction similar to that obtaining outboard so that the isobar pattern remained swept back at the wing roots. Work had been done at the Aircraft Research Association in modifying wing thickness distribution to straighten the isobars up to M = 1.2.

In reference to Dr. Lock's comments on model tests, Mr. Whitcomb pointed out that small models tested at low Reynolds numbers could give wrong results The conditions in the boundary layer were important and the pressure gradients produced, not the shape itself, were important.

DR. ING. G. V. LACHMANN, of Handley Page, Ltd., observed that some thought that the high subsonic/low supersonic régime was somewhat *passé*, the emphasis being upon hypersonics. However, the present contraction of the industry so far as manned military aircraft were concerned emphasized the importance of the slower civil transports. These would be subsonic for a very long time, operating very close to M = 1.0. Eventually there would be supersonic transports in the full Area-rule régime. He considered the lectures to be of very great value.

In answer to questions by MR. L. B. JONES, of the English Electric Co., Ltd., regarding the drag of nose air intakes, Mr. Whitcomb said that it was difficult to decide what should be charged to the engine and what to the airframe.

PRIVATE FLYING

H.J.C.'s Club Commentary:

An International Rally

More Chipmunks

New from Down Under

● MR. R. W. SPEARS, president of the **Channel Islands Aero Club,** writes that the fourth international air rally is to be held at St. Peter over the week-end of May 9-11. The rally has been fixed for that date as May 9 is Liberation Day in the Channel Islands and a public holiday. That evening a banquet and ball is to be held, festivities extending into the early hours of the Saturday. The club expects to arrange accommodation at the Portelet Hotel, and intends to put a club member and a car at the disposal of the crew of each visiting aircraft.

There was no rally last year because petrol rationing was in force, but the club hopes to make up this year for the omission by planning a really big rally.

● LATEST club to acquire a Chipmunk is the **Exeter Aero Club,** which flies from Exeter's airport at Honiton Clyst. The aircraft, G-AORN, is almost ready for use, and should be in service in February.

In 1957 the club flew a total of 1,666 hr., an improvement of 344 hr. over the 1956 total, the figure for last December being 151 hr. The increase, the club states, was not caused entirely by good weather, but also by hard work put in by the staff in getting members into the air as much as possible. Fourteen P.P.L.s were gained, and 17 first solos flown during the year. In December, S. J. Nelson got his licence, and B. A. Wiscombe flew his first solo.

The new briefing room and library have been put to good use, specially on bad-weather days, and the instrument section has been a centre of interest.

The club points out that the cost for the 200 hr. necessary for the C.P.L. is £650-£700 at Exeter.

A pilots' supper is scheduled for February 8, and a club dance is to be held on March 21.

An interesting visitor to Exeter just before Christmas was Admiral Boyne, U.S.N., who commands the NATO forces in North-West Europe, in his Sky-master. He was to present prizes at the Dartmouth Naval College and when he left on the following Monday he generously took with him a party of cadets who were to spend their vacation in London.

● ANOTHER CLUB which has become Chipmunk-conscious is the **Plymouth and District Aero Club** at Roborough, and G-AORV should be operating in February or March.

This club's total for 1957 was 3,282 hr., a figure which compares very favourably with previous yearly totals: 1,703 hr. in 1954; 1,970 hr. in 1955; and 2,434 hr. in 1956. During 1957, 20 P.P.L.s and four C.P.L.s were gained by members; 32 first solos were flown, 33 hr. night flying were recorded (between September and December); five night first solos were made and 19 parachute drops were made, including one by night.

Latest to get their licences are C.C.F. Cdt. Sgt. C. A. Parsons, S.P. Pak, and A.T.C. Cdt. Sgt. T. J. McDonald.

To commemorate the club's 30th anniversary, a dinner/dance is to be held at the Moorland Links Hotel at Yelverton on February 14.

SCHOOL CAPTAIN.—Peter Gale, 18, who is learning to fly with the Fair Oaks Aero Club, is captain of Ottershaw School, Surrey, and a member of the A.T.C.

● AT PERTH, the **Scottish Aero Club** flew 442 hr. more in 1957 than in 1956, which has come about largely by an increase of 505 hr. in A.T.C./C.C.F. cadet flying. During the year 16 members and 22 cadets gained their licences. The J. C. Henderson Cup—for the member gaining highest marks in his P.P.L. tests—has been won by A. Band; J. Watson and D. Grieve came second and third.

● IN AUSTRALIA, the **Royal Queensland Aero Club** has begun preliminary design work on a new four-seat low-wing monoplane known as the PL.9. It has been designed by Luigi Pellarini, well known as the designer of the PL.7 Tanker agricultural aircraft, and is to be produced specially to meet the club's requirements. Construction is scheduled to begin shortly at Archerfield, Brisbane.

The PL.9, a fully aerobatic aircraft with a fixed nose-wheel landing gear, is to be powered by a 150-h.p. Lycoming 0-320 engine, which should give it a maximum speed of 145 m.p.h. The wing span is 34 ft. and the loaded weight 2,100 lb.

A French Club Aircraft

AMONG the two-seat light aeroplanes operated by flying clubs in France is the Nord N.C.854. It has a 65-h.p. Continental A-65-8 engine driving a two-blade fixed-pitch Chauvière or Merville propeller, and is a metal structure with fabric covering.

The N.C.854 is a development of the N.C.850 which, appearing in 1947, was one of the first French post-War designs in this category, and which was produced by the S.N.C.A. du Centre, a company taken over by Nord in 1949. Immediately preceding the N.C.854 was the N.C.853, powered by a 75-h.p. Minié engine. About 100 of the latter were produced for the Service de l'Aviation Legère et Sportive. A military development, the N.C.856A Norvigie, was produced for the French Army.

Illustrated is the N.C.854, F-BFIB, which is operated by the Aéro-Club Air France.

DIMENSIONS.—Span, 36 ft. 11 in.; length, 22 ft. 5 in.; wing area, 166.2 sq. ft.

WEIGHTS.—Empty, 800 lb.; normal loaded, 1,320 lb.; maximum permissible loaded, 1,410 lb.

PERFORMANCE. — (N.C.853)—Maximum speed, 102.4 m.p.h.; cruising speed, 87 m.p.h.; landing speed, 40 m.p.h.; service ceiling, 11,480 ft.; cruising range, 310 miles; take-off run, 126 yd.

Throttle Benders at 119 Piccadilly

ONLY the hazards of snow and ice prevented the R.Ae.C. dinner to Flt. Lt. H. B. Iles, the 1957 British Air Racing Champion, and to Mr. Fred Dunkerley, winner of the King's Cup Air Race, 1957, from being overfilled. There had been more applications for seats than space permitted. Those who did battle through, and some came from the far places of these islands, heard Mr. Dunkerley make a vigorous call to the British aircraft industry to come back into the lightplane business with a successor to the Gemini and a competitor to the Piper Apache, of which he asserted some 10,000 had been sold.

After the first-class dinner had been eaten, Colonel Preston, the secretary-general, read out telegrams from the Hon. Peter Vanneck, Beverley Snook and J. M. Donald. He gave particulars of the National Air Races to be held at Baginton on July 10-12 (see THE AEROPLANE for December 6). He was at pains to make clear to the company the reason why the numbers selected for the King's Cup from each heat had been narrowed down to six. The point was well taken!

In discussing the Lockheed Aerobatic Trophy he reported that the Russians were planning to enter this year. He remarked in jocular fashion that he understood that they were not prepared to let the Czechs win again. At which a voice piped up and said "Who said we (the British) were either!"

There were no other races scheduled for this year. In his view the National Air Races were acquiring an international status in the same way as "Farnborough" had come to be synonymous with the S.B.A.C. Display. They intended, so long as the city supported them, to go on holding the event at Coventry.

MR. STEWART SCOTT-HALL, in his new capacity as chairman of the Air Racing Committee, then presented replicas of their trophies to Messrs. Iles and Dunkerley. The former admitted to achieving two ambitions: first to becoming air racing champion and second to achieving fame on the back page of a Sunday newspaper. He paid a tribute to the companies who supported the racing, to the handicappers and to the marshals and other assistants.

MR. DUNKERLEY spoke with feeling on the subject of taxation and the woeful effect it had on those who wished to pioneer. He then disclosed he had cherished the idea of winning the King's Cup for nine years. He recalled how he had decided to learn to fly in 1947 at the age of 42. At the time he was stranded in S. Africa between Johannesburg and Kimberley; chartering an aeroplane he was impressed with the pioneering spirit of the ex-R.A.F. pilot who flew it.

He was proud indeed to have achieved his ambition. He believed he was the oldest pilot to have won the King's Cup. He was the only male Lancastrian to have done so, and the only member of the Lancashire Aero Club to have done so.

Before this part of his speech he had asked why British aircraft manufacturers did not produce a medium light aircraft. He made it clear he was referring to twin-engined machines by explaining that the last had been the Gemini, now obsolescent. Indeed, it was completely out of date. A British light twin should be built to knock the Piper Apache for six. This was selling in thousands and he saw three at Le Bourget when he last passed through the aerodrome.

In conclusion he called on Nat Somers, who was to make a presentation to Philip Mayne, the official timekeeper. This turned out to be a statuette of Philip, starting-flag aloft, standing on a piece of green alabaster aerodrome. Taken completely by surprise at this tribute from the Throttle Benders, Mr. Mayne was somewhat slow in getting away. But he made his gratitude obvious and disclosed that he had taken the decision to retire as starter when he reaches 55 and, to this end, this year Mr. Cyril Audrey is to assist him.

GLIDING NOTES

THE MOTION before the basement, said Ken Owen at the Kronfeld Club on January 15, was "that this House wants gliding in comfort and joy." In the further course of his chairmanship of the debate, he found it necessary to rule: (a) that personal remarks are in order; and (b) that speakers should not confine their remarks to plumbing arrangements at gliding clubs.

At first sight one might have expected everybody to plump for comfort, but it can only be got at a price, and the price is not to be reckoned entirely in money, as the opposition pointed out in building up their case. However, an important aspect of the case for comfort was put by Wally Kahn, the proposer, who prophesied increasing restrictions which are likely to be put upon gliding by the efforts of commercial aviation to keep all of the sky for itself, so that in the course of the next decade gliding will eventually be confined to the neighbourhood of each club. To compensate for this, more amenities would be demanded by club members. Such a prospect evidently sounded so depressing that nobody else raised the point.

"Who has ever seen a pundit in a club bunkhouse?" asked Wally. True enough, nobody claimed to have done so, and his supporter, Beryl Stephenson, rubbed it in by reminding the audience that such comfort-loving pundits were responsible for two World Championship wins.

David Carrow, leading against "this decadent motion," declared that achievement and adventure are the life-blood of gliding, and it wasn't the "comfort-and-joy brigade" who gave us Nympsfield, the Cook compass, the Irving total-energy variometer, and numerous other benefits which he listed.

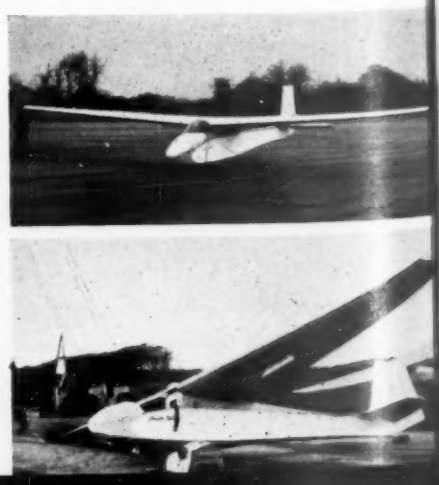
STILL awaiting achievement in England are the 500-kilometre distance, a flight along the sea-breeze front to Land's End, and soaring from wave to wave all the way from Anglesey to the Mountains of Mourne. Carrow's implication was that we should not do such things if we concentrated on comfort. And Mike Gee, supporting him, asked the assembled company if they wanted to become a lot of softies.

In view of what was said earlier, Carrow's three proposed long-distance flights will have to be done pretty soon, long before we are through with the frustrations which the next decade holds in store. But soaring flight is still, after all these years, in the exploratory stage, and of what other sport can that be claimed as its outstanding feature? In the latest Meteorological Office report on "Air Flow over Mountains" (Met. Reports No. 18), by G. A. Corby, which deals with waves in the air, gliders are mentioned over and over again, and the magazine *Gliding* is found in the list of references.

* * *

SIR ROGER CONANT, M.P., while not going to such lengths, thought there was a case for allowing the busy man to come along and fly without having to do his share of winch-driving and other chores—providing, of course, that he pays extra for the privilege. This would help to bring in various influential people who are in a position to combat any threatened encroachments by airways, which they would gladly do, once they had tasted the joys of soaring.

Another question Sir Roger raised was that of teaching Air Training Corps cadets to soar, instead of merely to glide; i.e., to be trained up to the "C" instead of only the "B" certificate. This controversy was thrashed out in THE AEROPLANE just over ten years ago: on the one side is the argument that the only national purpose of gliding is as a preliminary to soaring; and on the other, that for a given outlay, many more cadets can get a chance to handle gliders if they are stopped short at the "B" certificate. The danger is that someone will come along and try to apply the latter argument to the whole country, just to produce impressive statistics which will deceive the non-gliding public and politicians. It is a tempting way of becoming known as "the man who got the Youth of Britain into the air."—A.E.S.



BRITAIN'S LATEST.—On the right are two views of the new 12-metre Slingsby T-45 Swallow single-seat sailplane, which is now being tested at Lasham.

CORRESPONDENCE

David McIntyre's First Parachute Jump

WHEN David McIntyre (THE AEROPLANE, December 20 last) joined 602 Sqn. in 1926 he was, I think, the third Pilot Officer to join (the others having been myself and Drew).

During annual training the rest of us had done, so-called voluntary, pull-off parachute drops. But, for some reason, Mac was not available. He did not like to be out of it, and in 1927 put in an application to be allowed to do so. This could not be arranged and the matter was forgotten—we thought.

One hot summer's day, in 1927, he turned up on the apron with another pilot (Back, I think) and got permission from our Adjutant/Instructor for the two of them to go up together in a dual Avro and practise aerobatics, Mac to be in control.

At a fair height the Avro appeared to commence a slow roll, but when on its back something fell from it. Then someone shouted: "My God, it's a person." Sure enough, in due course, a parachute opened and went off into the countryside with its owner.

The Avro remained inverted for some time, finally flicked over, and with a now dead engine managed to land on the airfield. It was Back who reported: "Mac said we'll do a slow roll. I thought we'd stuck upside down a long time; and said some jeering remark into the tube but, getting no answer, I twisted round to look. And there was no one there—I looked down, and there was Mac going down by 'chute. So I took over."

I later discovered that Mac had had no proper instruction how to use a parachute.

Piccadilly, London, W.1. COLIN PARKER.

Sputnikalities

REFERRING to some of the "Sputnikiades," especially in THE AEROPLANE issues of October 25 (page 604), December 13 (pages 861 and 904) and November 15 (page 752), may I be permitted to think and say a few things, not exactly flattering the Western World—especially our thinking that space travel is only possible with vehicles overstuffed with electronic gadgets. As rocket history shows such highly complicated things never work properly and didn't help the U.S. satellite launching.

What I can't quite understand is: If U.S. radar stations in Turkey actually picked up telemetry signals and telescope-tracked pre-Sputnik missiles of the Soviet ICBM and IRBMs since 1953, how is it that up to now in the Western World nobody seems to know the slightest thing about how the Ivans launched their Sputniks?

Look at the simple way the Russians solved the problem of letting out "stall bleed air" between compressor stages by releasing and tightening hydraulically a simple steel band around openings in the compressor casing of their powerful turbojet AM-3, used in the Tu-104. Would it not be a safe bet to assume that they will use their masterly ability to take over all good and ingenious ideas the Western World has ever invented, "simplify and add lightness" in the actual design—and, as nobody in Russia seems to worry about costs, just make a really big thing. (The same as we could do too if we had no undisciplined rivalry, not only between armed services but also in all departments of our scientific research, development and test centres.)

The Russians know all about the many unsuccessful take-offs of V-2s from Peenemünde and the misbehaviour of American "tail-sitter" rockets. Why then, may I ask, should they waste time in trying out electronical-stabilizing and all that tiring check-list nonsense with showy "count-downs," waiting for the proper wind and so on? Why all this fuss, if all the World knew long ago that quite a heavy rocket could be lifted into the sky by well-developed and powerful "winged" aeroplanes, that a human pilot is far cheaper to do the job of counteracting wind-drift and other stability setting?

If such a heavy "space-rocket" is lifted up to about 40,000 ft., all the pilot of the winged rocket carrier has to do is to maintain proper take-off angle of the rocket at the release, press the buttons for igniting rocket fuels, let the thing just fall off his plane—and go home for another take-off. The rocket would thus have already sufficient speed, in fact near-sonic velocity, to stabilize itself (by simple aerodynamic surfaces) spinning around its axis. All this has been done many, many times before and it works without any complicated electronery.

The Sovexport film "Red Moon" shows a "twin-fuselage" plane carrying a two-stage rocket. Why shouldn't the Ivans use a "twin-Tu-114," coupled just in the same fashion as was done by Heinkel with his "twin He.111" in the last War? Such a combined Tu-114, perhaps modified from turboprop into turbojets, might easily lift more than 100 tons of rocket about 40,000 ft. high and start the rocket with a take-off speed of near sonic velocity.

Even if the overall fuel saving of such a take-off device is only about two-hundredth of the total fuel weight—according to Kentigern in THE AEROPLANE—the system has great advantage because such a "first-stage-booster" can be used again and again and will not be lost, as a "tail-sitter" first-stage rocket will unavoidably be, in spite of parachute landing.

Wiesloch/Heidelberg, Germany. JOS. REDER.

Wroundabout

Sound Investment. The bright lads of Boeing's publicity department have offered me stock in a subsidiary company formed to exploit a modification of their 707's engine sound suppressors involving punching holes in each suppressor's 21 tubes, fitting clamper valves wired to a series of black boxes connected to a tape recorder. Inhabitants near airports would be treated to concerts, time for singing commercials

would be sold and suitable anthems would be played over foreign countries. If they will modify the mod. so that a sustained, soothing organ chord can be piped into the quiet cabin to provide the American Sixth Freedom—Freedom from Silence—then I'll invest in Boeing Electronic Air Tunes (or BEAT), Inc.

✱

Too Much, Too Long. See what happens when a columnist diverts into maths. For my report (p. 66, January 17) on Fairey's Long-service Assn. dinner, I worked out the attendance at 750. Actually, there were present only 408, using the word "only" in the sense of the story about the student who fainted when a lecturer forecast the end of the World in 11 million years' time. When the student revived, the lecturer asked him: "Why should you be upset by the World ending in 11 million years?" "Eleven?" said the young man, with pathetic relief, "I thought you said seven."

✱

As I sat musing one day,
Sad and lonely,
And without a friend,
From out of the gloom
A voice came to me
Saying "Cheer up,
Things could be worse."
So I cheered up
And sure enough,
Things got worse.

✱

Requiescat in Parks

Amiable friend, tough ex-test pilot, engineer and director, Jacques Lecarme of Sud-Aviation sends me this copy of a sign he saw in Wichita, Kansas:—

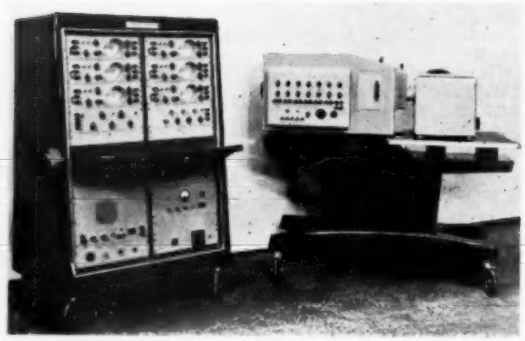
A FINE FUNERAL FOR $50.
Mortuary Since 1863.
FREE PARKING FOR CUSTOMERS.

✱

Wren Wrong. Last week, in Wroundabout, I put Rolls-Royce engines in the DC-8s ordered by S.A.S., much to the surprise, I'm sure, of my good friends at Pratt & Whitney, who could justifiably show me the item in their order book: "Please deliver by 1960 enough of your JT4A-3 engines to power seven Douglas DC-8s—Yours ever, S.A.S." From Derby there has been no comment, not even to suggest the revised spelling "Wrolls-Wroyce."

by Wren

NOTES AND EVENTS



The MUR Universal Oscillograph produced by Southern Instruments, Ltd., and referred to on this page. There are two models available, providing up to 6 and 12 channels respectively with time markings.

INSURANCE MOVE.—Bray, Gibb and Co., Ltd., insurance brokers, have moved their West-end office from 166 Piccadilly, London, W.1, where they have been since 1908, to Colonial House, 30-34 Mincing Lane, E.C.3. Mr. W. H. Cuthbert, a director, who joined the firm in 1906, will continue to direct the West-end division.

TROOPING SEATS.—Aircraft passenger seats designed and built by Short Bros. and Harland, Ltd., are to be installed in the Britannia 253s which the company is building for the R.A.F. Comprising 1,350 passenger places, there are 60 double and 410 triple units under construction. The seat is a new lightweight type with a framework of pressed light alloy and upholstered with foam plastic. It is designed for easy stowage, and tests have proved that it will withstand a force of 9 *g* facing either forward or aft. High-density troop-carrying is catered for by the reclining angle of the back of the seat, which can be adjusted to eight positions.

SOUTHERN PRODUCTS.—Recently produced by Southern Instruments, Ltd., of Camberley, is the MUR Universal Oscillograph. It is a new type of cathode-ray oscillograph developed to provide multi-channel recording equipment of great flexibility. The recording tubes, 3 in. in diameter, are separate from the main equipment, housed in a cabinet to which the camera and optical system are fitted. A master distributor panel in this unit is fed with power supplies and driving voltages from an amplifier console. Within the recording unit the tubes are mounted in adjustable clamps on a short steel column fixed to a base sliding on rails, enabling the tubes to be moved towards or away from the camera lens.

NEW SEALS.—Recent developments by Precision Rubbers, Ltd., of Bagworth, Leicester, are a wide range of silicone rubber seals with improved characteristics for use in airframe construction, and Prescollan, a rubber-like material with exceptional resistance to abrasion, cutting and tearing.

D. AND B. DISTRIBUTORS.—Sir W. H. Bailey and Co., Ltd., of Patricroft, Manchester, have been appointed sole distributors for the flow-indicating equipment produced by the Dukes and Briggs Engineering Co., including the Telicator visual flow indicator.

OVER CEYLON.—A Canso amphibian of Kenting Aviation, Ltd., of Canada, is in Ceylon to do aerial geophysical work under the Canadian Colombo Plan. It is equipped with geophysical devices and the work is part of a natural resources inventory of the whole island contracted by the Canadian Government.

Aviation Calendar

February 1. — British Interplanetary Society lecture, "Meteoric Hazards to Space Flight," by Dr. N. H. Langton, M.Sc., A.Inst.P., in the Tudor Room, Caxton Hall, **London,** S.W.1, at 18.00 hrs.

February 4. — R.Ae.S. Luton Branch lecture, "Development of the Armstrong Siddeley Viper," by W. H. Lindsey, M.A., F.R.Ae.S., in the Napier senior staff canteen, **Luton Airport,** at 18.15 hrs.

February 4.—Inst. of Civil Engineers lecture, "The Use of Aerial Photography by Railways," by N. E. V. Viner-Brady and H. M. Pearson, at Gt. George St., **London,** S.W.1, at 17.30 hrs.

February 4.—R.Ae.S. Glasgow Branch, Pilcher Memorial Lecture, "Recent Progress in Turbojets and its Effect on Aircraft Design," by J. L. Edwards, B.Sc., A.M.I.Mech.E., A.F.R.Ae.S. (de Havilland Engine Co., Ltd.) at the Royal College of Science and Technology, Duke St., **Glasgow,** at 19.15 hrs.

February 5.— Kronfeld Club lecture, "The Oxygen Story," by G. Melvill-Jones (R.A.F. Inst. of Aviation Medicine), at 74 Eccleston Sq., **London,** S.W.1, at 20.00 hrs.

February 5.—R.Ae.S. London Airport Branch lecture, "Noise," by Professor E. J. Richards, M.A., B.Sc., F.R.Ae.S. (Southampton University), at **London Airport,** at 18.00 hrs.

February 6.—Inst. of Prod. Engineers, 1957 Viscount Nuffield Paper, "Technical Education for Production Engineers," by the Rt. Hon. The Lord Hives, C.H., M.B.E., D.Sc., LL.D., in the Large Lecture Theatre, Engineering Faculty, **University of Bristol,** at 18.30 hrs.

February 6.—Kronfeld Club film show, "Twelve O'clock High," at 74 Eccleston Sq., **London,** S.W.1, at 20.00 hrs.

February 6.—R.Ae.S. Bristol Branch lecture, "Design of Civil Aircraft," by D. P. Thorne, in the Conference Room, Bristol Aircraft, Ltd., Filton House, **Bristol,** at 18.00 hrs.

February 7.—Helic. Assn. of Gt. Britain lecture, "Wind Tunnel Testing of Helicopter Models," by M. S. Hooper, F.R.Ae.S. (Fairey Aviation Co., Ltd.) in the R.Ae.S. Library, 4 Hamilton Place, **London,** W.1, at 18.00 hrs.

February 7.—A.B.A.C. Annual Dinner at the Waldorf Hotel, Aldwych, **London,** W.C.2, at 19.00 hrs. for 19.30 hrs.

February 10.—Inst. of Transport Brancker Memorial Lecture, "The Control of Air Traffic—Origin, Development and Future Requirements," by Air Cdre. W. E. G. Mann, C.B., C.B.E., D.F.C. (M.T.C.A.) at the Jarvis Hall, Royal Inst. of British Architects, 66 Portland Place, **London,** W.1, at 17.45 hrs.

RADAN ON TEST.—General Precision Laboratory's Radan Doppler-principle navigation system is being tested by P.A.A. on a DC-7C. A recent announcement said that 18 transatlantic crossings had been made during which the 89-lb. Radan equipment proved "extremely accurate."

INFORMATIVE LEAFLET.—Muirhead and Co., Ltd., of Beckenham, Kent, has produced a leaflet describing the salient characteristics of Muirhead synchros, servomotors, resolvers, motor tachometers and tachometer generators which are in production. The information is arranged for easy reference, and forms a useful key to the more detailed Muirhead synchro data sheets. Copies of the leaflet are available on request.

Company Notices

NEW COMPANIES

Charles Butler Associates Design for Industry, Ltd. (597,231).—Private co. Reg. Jan. 16. Cap. £200 in £1 shs. Objects: To carry on the business of designers of and consultants upon the fitting, layout, styling and decor of the interior of aircraft, etc. Subscribers (each with one sh.): D. Ian Wilson and P. J. Gaynor, solicitors, both of 12 Whitehall, London, S.W.1. The first directors are to be appointed by the subscribers. Solrs.: McKenna and Co., 12 Whitehall, London, S.W.1.

Fasteroutes, Ltd. (597,300).—Private co. Reg. Jan. 16. Cap. £1,000 in £1 shs. Objects: To arrange and conduct air flights to Norway and other parts of Europe and elsewhere, etc. Directors: Raymond A. Cook and Dorothy Cook, both of 23 Lewisham Rd., Dover; Albert J. Wilkins, Havenfield Hall, Hawkinge, nr. Folkestone, all directors of Raymond Cook, Ltd., and Invicta Tours, Ltd. Sec.: Raymond A. Cook. Reg. off.: 5-9 Folkestone Rd., Dover.

Langford Patents, Ltd. (597,304).—Private co. Reg. Jan. 16. Cap. £1,000 in £1 shs. Objects: To acquire patents and rights relating to improvements in metal stampings for aircraft, machine tools and engineering specialists, etc. Directors: Harry Langford (chairman), director of Harry Langford, Ltd., and Lorna C. Langford, both of 43 Waverley Rd., Kenilworth, Warwicks. Sec.: Rhoda E. Edmundson. Reg. off.: 31 Bedford Row, London, W.C.1.

Orion Aircraft Services, Ltd. (597,350).—Private co. Reg. Jan. 17. Cap. £100 in £1 shs. Objects: To carry on the business of air transportation for passengers, mail, freight, etc. Subscribers (each with one sh.): Alan G. Gilbert and Malcolm Hurwitt, solicitors, both of 91 South Rd., Southall. Peter E. Palmer, Marshwood, Fairlie, Ringwood, Hants, director of Orion Airways, Ltd., etc., is the first director. Sec.: P. Cross. Solrs.: Wilson A. L. Houlder and Co., Southall. Reg. off.: Baginton Civil Airport, Coventry.

Percival Aircraft, Ltd. (597,450).—Private co. Reg. Jan. 20. Cap. £100 in £1 shs. Objects: To carry on the business of aeronautical experts, etc. Subscribers (each with one sh.): Edgar W. Percival, 72 Chesterfield House, Curzon St., London, W.1, aircraft designer (director of Edgar Percival Aircraft, Ltd., etc.); Arthur V. Richardson, 55 Upper Berkeley St., London, W.1, gentleman. Edgar W. Percival is governing director. Sec.: A. V. Richardson. Reg. off.: 72 Chesterfield House, Curzon St., London, W.1.

W. Sim (Eire), Ltd. (16,703).—Private co. Reg. in Dublin, Oct. 1, 1957. Cap. £10,000 in £1 shs. Objects: To manufacture and deal in aerial conveyances of all kinds, and the component parts thereof, etc. Subscribers (each with one sh.): Richard Sutcliffe, "Thornfield," Warren Avenue, Eldwich, Bingley, Yorks, company director; and John P. King, 13 South Anne St., Dublin, solicitor. First directors not named.

INCREASE OF CAPITAL

Airflow Developments, Ltd. (550,374). Manufacturers of and dealers in electrical instruments, etc. 121 New Rd., Booker, High Wycombe. Increased by £4,000 in £1 ordinary shs., beyond reg. cap. of £2,000.

Personal Notices

BIRTHS

Byford.—On January 15, at Ely, to Angela (*née* McLean), wife of Flg. Off. G. Byford—a son.

Earle.—On January 12, at Douglas, to Elsie (*née* Hibbs), wife of Flt. Lt. B. P. Earle—a son.

Hawthorne.—On January 16, at Carshalton, to Jennie, wife of Sqn. Ldr. J. F. Hawthorne—a son.

Morgan.—On January 13, at Driffield, to Doreen, wife of Flt. Lt. V. J. Morgan—a son.

Penrose.—On January 13, at Sleaford, to Dorine (*née* Stewart), wife of Flt. Lt. J. Desmond Penrose—a daughter.

DEATH

Kirkpatrick.—On January 16, in a flying accident, Flt. Lt. Barry Campbell Kirkpatrick.